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ILLINOIS TECH ENGINEER
AND ALUMNUS

October, 1945



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"5,000 *Miles without a* Blowout"

Remember back in 1920 when 5000 miles without a blowout was something to brag about? In those days a tire and tube cost around thirty-five dollars...and tire changing was a back-breaking job that called for overalls, hammer and pinch bar, plenty of muscle and a sweet disposition.

Tire making has come a long way since those days—thanks to the progress of the rubber manufacturers and also to the efforts of those industries that supply the compounding materials. Outstanding among these is carbon black. For our modern rubber tires—both natural and synthetic—owe to carbon black a high percentage of their great strength, resilience, flex and abrasion resistance, and durability. Without it synthetic rubber would be useless for tire production!

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CAMPUS NEWS

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD

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". . . even more than in the past the laboratory will emphasize research in pure science—continuing and expanding the work begun by Dr. Whitney and the late Dr. Steinmetz forty-five years ago."

C. E. Wilson
President, General Electric Company

A New Idea

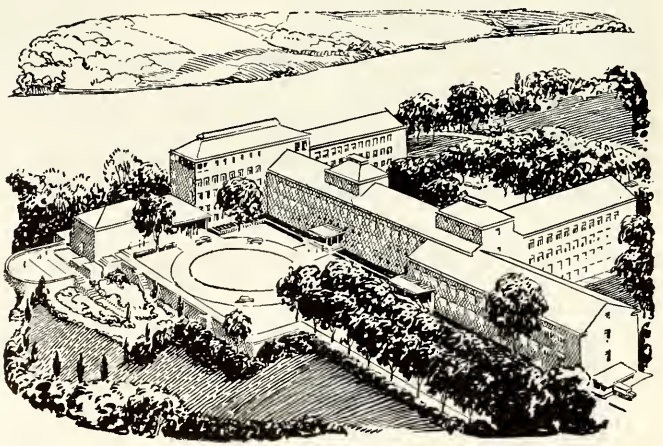
In 1900 Dr. Steinmetz, Elihu Thomson, A. G. Davis, and E. W. Rice, Jr. originated the idea of a laboratory that would be devoted to the problems of fundamental research, without immediate concern for commercial results.

Up to then fundamental research in this country—what there was of it—had been largely left to colleges. In 1900 industrial laboratories had not grown beyond the status of "trouble stations" maintained only for the immediate needs of the factories.

They started the G-E Research Laboratory from scratch—in a barn behind the Steinmetz home—a far cry from the $8,000,000 laboratory building planned for peacetime America.

Years of research and engineering have built the laboratory into a veritable "House of Magic." It meant the work and ideas of men like Dr. W. R. Whitney, Dr. W. D. Coolidge and Dr. Irving Langmuir. In 1914 the laboratory moved to a new brick structure—then the last word in laboratory construction. Research had come into its own.

The laboratory will now move to a more spacious location. Plans have been approved, the site has been chosen, and it is hoped that construction can start within six months. The site, five miles east of Schenectady, offers special advantages for a "House of Magic" of the future. On a rocky cliff near the Mohawk River, it's particularly adaptable to General Electric's work with radar, television, high-frequency, jet engines, and x-ray.



This new building—as an artist sees it—will be from two to five stories in height and will include 300,000 square feet of laboratory working space.

In the past forty-five years G.E. has contributed to better living in America—not only through new developments in electricity, metallurgy, electronics, and chemistry, but also through reduced cost and increased efficiency, as in the modern incandescent lamp. In 1923 a 60-watt lamp cost 40 cents. Today the 60-watt bulb gives 50% more light for the same current and costs only 10 cents, plus tax—thanks to G-E research.

Research Staff Will Grow

An expanded staff will carry on this research in a laboratory built on a 219-acre estate. Looking ahead 15—or even 20 years—still further expansion may be required, such as smaller structures for special purposes, and a pilot plant for new chemical processes. All this requires not only a building that is immediately suitable, but one with grounds around it for other buildings.

But the ideas evolved in this new laboratory will not be the ultimate in research. The word *research* implies a continuing process. It is unlikely that the physicists, chemists, and engineers of our country will ever stop prying into the secrets of fundamental science. In the words of Dr. Coolidge, "A research laboratory is essentially a group of men in a congenial atmosphere, engaged in *extending* the frontiers of knowledge." *General Electric Company, Schenectady, New York.*

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All the various elements of an electric washing machine, yes, even all the aluminum was on earth when Lady Macbeth delivered her famous soliloquy to the bleak Scottish moors . . . but the best kilted necromancers of her Highland Court lacked the "know-how" to imagineer them.

We invented the word "Imagineering"* to describe how Alcoa, and other great groups of technicians go about the job of supplying the methods, materials and machines of modern life.

Today . . . Youth laments that there are no new lands to discover, no new frontiers to cross. And yet, in the uncharted kingdom of the mind, hardy pioneers are daily spanning new horizons in the twin fields of invention and adaptation. Aluminum offers exciting new opportunities to every intrepid Imagineer . . . who seeks new industrial worlds to conquer.

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*Imagineering equals the union of imagination, man's oldest mental development, and engineering his newest. Together they are the key to progress.

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ALCOA ALUMINUM

OCTOBER 1945

ILLINOIS TECH ENGINEER
AND ALUMNUS

VOLUME 11 NUMBER 1

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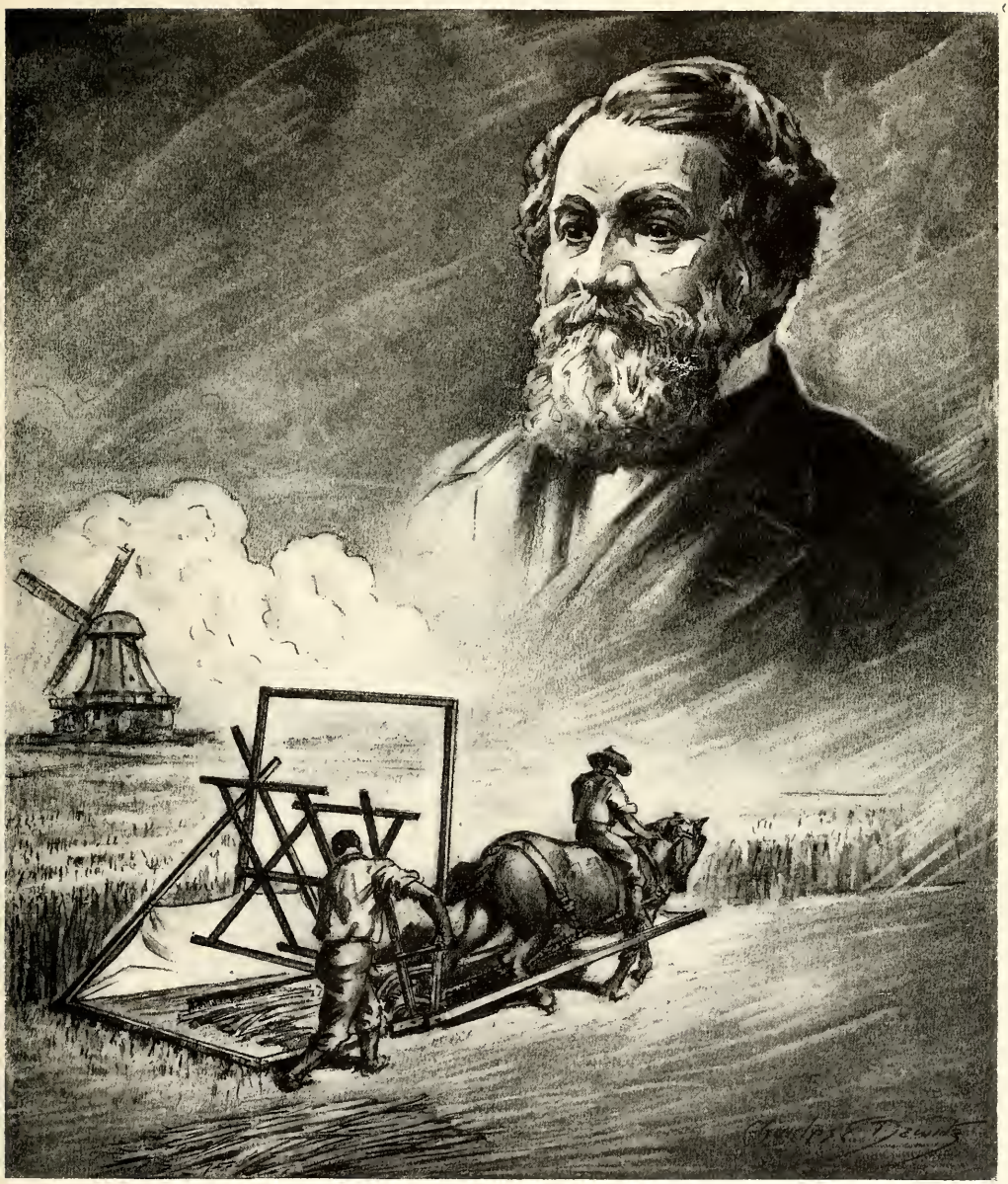
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ALUMNI SECTION

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Published in October, December, March, and May. Subscription rates, $1.50 per year. Editorial and Business Office, Illinois Institute of Technology, 3300 Federal Street, Chicago 16, Illinois.

CYRUS H. McCORMICK — 1809 - 1884



Cyrus H. McCormick was born February 15, 1809; *the date is noteworthy, being three days after the birth of Abraham Lincoln.*

During the war of secession which centered about the slavery question Edwin M. Stanton, Secretary of War, said, "Without McCormick's invention I fear the North could not win, and the Union would be dismembered."

Cyrus H. McCormick died at his palatial home in Chicago in 1884. *His parting words were "Work, work."*

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• • •

Charles A. Scarlott is editor of the WESTINGHOUSE ENGINEER.

* * * * * * *

Cover— The unusual shot on the cover of the electric service station was furnished by the courtesy of Commonwealth Edison Company.



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When your doctor writes a prescription calling for certain pharmaceuticals, the chances are that one or more Dow products were used as basic materials in their manufacture. The same is true when you buy a standard proprietary remedy over the counter in your neighborhood drug store. Among the long list of pharmaceutical chemicals Dow produces for these purposes are Chloroform, Epsom Salt, Acetyl Salicylic Acid, Iodine, Phenol, Monochloracetic Acid, Acetphenetidin and Potassium Bromide. Recently, with the aid of Methocel, a Dow product, a remarkable new method for the treatment of burns has been developed; and the first commercial production of dl-Tryptophane, one of the essential amino acids, has just been announced by Dow.

a healthy nation relies heavily on chemistry

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TUNE IN THE DANNY KAYE SHOW EVERY FRIDAY
10:30 *P.M. EST CBS*

Mexican-American Conference
On Industrial Research

By

Paul D. Hermann

Proving conclusively that the range of scientific research need not be confined within linguistic or political boundaries, the Armour Research Foundation of Illinois Institute of Technology this month sponsored a highly successful Mexican-American Conference on Industrial Research.

For a full week, extending from September 30 through October 6, scores of outstanding representatives of government, industry, education and finance from both countries met in Chicago at the Foundation's invitation to study technological advancements in this country through panel discussions by competent speakers from related fields and inspections of various types of research organizations in the area.

Aimed to stimulate industry in both the United States and Mexico by bringing about a better mutual understanding of the scientific research and industrial endeavor both north and south of the Rio Grande, this conference may well prove one of the major steps in formulating a more closely-woven pattern for future inter-American industrial co-operation.

The original idea for such an undertaking grew out of the Mexican research project which the Foundation has been carrying on for the past year with a branch office in Mexico City under the direction of Dr. Francis W. Godwin, associate director.

Commissioned by the Banco de Mexico, this group of Foundation scientists have been engaged in studying means for raising technological standards for Mexican industry and, more specifically, in conducting a program of industrial research studies with the objective of creating additional well-founded industries in that nation.

Out of this project was born a clear realization of the need for closer joint discussion, on the high management level, of mutual problems and industrial research applications in order to attain a maximum degree of post-war productive efficiency.

Basic plans were outlined during the spring of this year, and these were met with such enthusiastic response that the size and scope of the conference, like Topsy, "just growed" by the day



Delegates to the conference flew from Mexico City to Chicago in a chartered Braniff Airways plane. ..The picture above was taken when they arrived at 3:30 a.m., September 31 at the Chicago Municipal Airport.

until nation-wide attention was focused on Technology Center when the first of two special planes of the Braniff Airlines swept into the Chicago Municipal Airport shortly before 3:30 a.m. on Sunday, September 30.

A group of about 50 delegates assembled for the first lap of the conference at 11 o'clock Sunday morning on the mezzanine floor of the Blackstone hotel where the conference headquarters were set up. Registering with executive secretary Ken Warren, the weary representatives were presented with badges on which were emblazoned "Mexican-American Conference on Industrial Research" beneath crossed flags of both nations and the seal of Illinois Institute of Technology.

Loading themselves into half-a-dozen waiting limousines, the group was driven north to Evanston where Dean O. W. Eshbach acted as host for luncheon in the faculty club of Northwestern University's Technological Institute. A tour of inspection of the modern and extensive facilities of the Institute followed after which the group drove through the rain to Great Lakes Naval Training Station where Admiral Arthur S. Carpender entertained the group briefly in the Officers Club. The Hosts Committee, headed by Chairman Frank Hecht, lived up to their name in the evening as they met with the Mexican guests for supper at the Old Elm Country Club, Lake Forest.

At 10 o'clock Monday morning the conference actually got down to business after Mayor Edward J. Kelley had tendered his official greetings. Dr. Henry T. Heald, chairman of the opening session, discussed the objectives of the conference and then introduced Harold Vagtborg, former director of the Foundation and at present director of the Midwest Research Institute in Kansas City.

Emphasizing that "research in the United States is destined to become a million dollar a year industry and is today limited only by the shortage of personnel and facilities," Mr. Vagtborg traced the industrial research pattern of the United States from its earliest beginnings in the '80's to its present status as the "pilot of industry."

After luncheon at the Chicago Club, John I. Yellott, genial director of research for the Locomotive Development Committee and former head of the Institute of Gas Technology, introduced Dr. Walter Bartky of the University of Chicago. The newly-appointed director of physical sciences spoke on "Fundamental Research in College and University Laboratories" and then conducted the entire group on a tour of the research laboratories along the Midway.



Mrs. Mary Chauvet registers Enrique Sarro at the opening of the conference.

Delegates to the conference were once more guests of the Hosts Committee at the Chicago Club for cocktails and supper in the evening.

The daily conference schedule followed much the same pattern of activity for the remainder of the week, with qualified speakers taking up one of the major phases of industrial research and discussing its characteristics, advantages and relative importance. Afternoons were filled with tours to outstanding research organizations in the vicinity which best typified the morning's discussions.

Tuesday, October 2, Dr. Edward Weidlein, director of Pittsburg's Mellon Institute, led off the panel discussion with a talk regarding research devoted to public service, after which Dr. Jesse Hobson, who heads Illinois Tech's Armour Research Foundation, mounted the speakers' platform to explain what makes the ARF tick. Topnotch personnel and a workable policy, rather than intricate chromium plated machines alone, are of utmost importance to successful research, he said.

Following a brilliant luncheon talk by Dr. A. A. Potter, acting president of Purdue University, on the training of research and scientific personnel, a tour of the Research Foundation was made.

A gala banquet in the Grand Ballroom of the Blackstone hotel in the evening, with James D. Cunningham, chairman of the General Committee, serving as toastmaster, featured a talk by Dr. L. A. Hawkins, former director of research laboratories for General Electric. Hugh N. Cross, lieutenant governor of the State of Illinois, also spoke briefly.



Dr. Henry T. Heald, president of Illinois Institute of Technology, and Gustavo P. Serrano, Mexico's minister of National Economy, at the Monday morning session.

Wednesday's program began with a visit to the Museum of Science and Industry in the morning with Major Lenox R. Lohr, president, leading the way. At the noon luncheon, Dr. Gustav Egloff, research director at Universal Oil Products Company, provided an unscheduled highlight when he revealed for the first time the invention of a small compact catalytic cracking unit which, by bringing the latest developments in oil refining within the reach of any small company, is expected to revolutionize the entire industry.

This announcement, which had not been scheduled for several months to come, was made at this time to give the Mexican guests a first-hand knowledge of the dividends which privately sponsored research programs, such as that of Universal Oil, pay to its sponsors.

In the afternoon the group inspected this company's laboratories before catching a six o'clock train to Madison, Wisconsin, where on Thursday they were shown an entirely different type of research work.

Headed by some of the outstanding individual research men in their field, assembled by the University of Wisconsin to carry on the work of the Agricultural Experiment Station, the conferees climbed over barbed wire fences, inspected dairy barns and were given an insight into the truly remarkable work being carried on in making farming a profitable undertaking through science.



Mexicans at the Monday night dinner showed their hosts an example of Mexican harmony.

Dr. E. B. Fred presided at luncheon, consisting of steaks, milk, cottage cheese, etc., from the University's own farms, after which Dr. I. L. Baldwin and Dr. Noble Clark discussed land-grant college research in general and the agricultural experiment station in particular.

In the afternoon, George M. Hunt, assistant director of the Forest Product Laboratories headed an inspection of the fine forestry laboratories after which the group returned to Chicago on two special club cars.

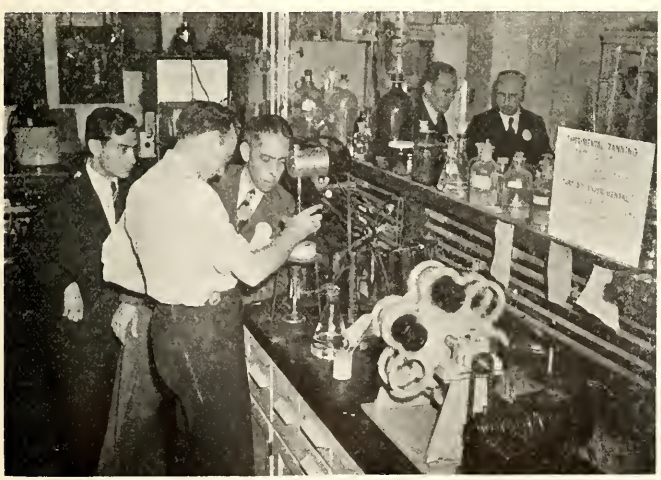
Friday's discussion panel devoted itself to the subject of standards for industry with George S. Case, vice-president of the American Standards Association, Eugene C. Crittenden, assistant director of the National Bureau of Standards, and David Levinger, vice-president of the Western Electric Company contributing their comments.

At luncheon Dr. Arthur S. Compton, whose prominent work in the development of the atomic bomb made him one of the best known disciples of research in the world, put in a surprise appearance and made an impromptu speech to the assembled audience. Dr. E. H. Volwiler then outlined recent developments in medical research before conducting a trip through the laboratories of the Abbott Laboratories, North Chicago, of which he is vice-president in charge of research.

Members of the Mexican Chamber of Commerce were hosts for dinner in the evening at the Stevens hotel, with Emilio Almada, acting Mexican Consul-General and E. B. Woolf, president of the Chamber of Commerce, presiding.

A trio of speakers, consisting of James D[illegible]mm, vice-president of the National City Bank of New York, Maurice Holland, industrial research advisor, and George Houston, of Houston and Jolles, wound up the regularly scheduled conference proceedings with a panel discussion of "Technology on the International Front" on Saturday morning.

A farewell luncheon, under the auspices of the Hosts Commtitee,



Mexican visitors inspect a tanning project at the Foundation which is being carried on as part of the Banco de Mexico research.

was followed by sincere expressions of appreciation and constructive descriptions of how the knowledge that had been accumulated during the week will be applied to the solution of Mexico's industrial research problems by many of the Mexican party.

Eduardo Villasenor, president of the Banco de Mexico, concluded with a brilliant analysis of Mexico's present status in attempting to progress to a point in the realm of research for industry whereby the standard of living of the entire country may be benefited through the increased utilization of her own raw materials. Chairman Frank Hecht said farewell in behalf of the conference sponsors—and the Mexican-American Conference on Industrial Research was written into the records.

Unlike a snowball rolling down a rooftop in the wintertime, the conference did not just automatically grow and develop into its final form without a tremendous amount of advance planning and co-operation on the part of individuals and organizations throughout both countries.

It is only proper that to a few of those individuals who particularly devoted themselves to the single purpose of making the conference into a medium for achieving an exchange of knowledge and experience between top-notch representatives of both Mexico and the United States, some expression of appreciation for their efforts in making a success of the undertaking be made.

Perhaps the greatest burden of responsibility, and thus the greatest credit, fell to a quartet consisting of Mr. Frank Hecht who capably headed the Sponsoring Hosts Committee; Dr. Jesse E. Hobson, director of the Armour Research Foundation and chairman of the steering committee; Dr. Francis W. Godwin, who did a great deal of the necessary preliminary work from his Mexico City office; and Kenneth Warren, executive secretary for the conference, upon whose desk fell nearly all of the vast amounts of detailed work which must be carefully arranged.

Thanks also should go to the other chairmen of major committees, Mr. James D. Cunningham of the General Committee and Dr. Henry T. Heald of the Technical Advisory Committee, to their fellow committee members, to all the speakers and toastmasters throughout the week.

To the Mexican guests themselves, every one of whom took a great personal interest in the activities and cooperated to the fullest extent, and to their president, Manuel Avila Camacho, who sent a quintet of personal representatives, goes particular credit and appreciation.

Few of the conference speakers talked "a mile a minute" but all of them talked at least two feet a second—and three representatives of the Foundation can prove it.

Russell Tinkham, Jack Kemp, and Don Hadley were in charge of recording the entire parley on two Armour magnetic wire sound recorders. The resulting spools of hair-thin wire, each complete set measuring a cool 60 miles, will be sent to President Harry S. Truman, c/o White House, Washington, D. C. and the Mexican President Camacho as soon as the complete proceedings have been transcribed from the wire by secretaries for bi-lingual reports for distribution in both English and Spanish.

Eduardo Villasenor was entrusted with a wire recorder to be presented to President Camacho on his return to Mexico City at the concluding session on Saturday noon. A specially plated Model 50, this recorder is of the type used by the Allied armed forces during the war just ended, and more recently to record the Japanese surrender proceedings aboard the U.S.S. Missouri.

The weather man was among the notable exceptions to the fine co-operation received — for the first three days of the conference Chicago was at its cold and rainy worst. Not only reception committees at each stop from Mexico City to Chicago, as well as an Army plane on the loose, but strong head winds held up the scheduled arrival time some six hours.

Mrs. Tom Braniff, wife of the president of the Braniff Airlines, headed the feminine contingent to the conference together with Mrs. Mary Chauvet, who served as interpreter during the week. Typically, their interests turned from the intricacies of industrial research to the fashion shops along Michigan avenue.

Needless to say the conference was conducted almost exclusively in English, and with but one exception the guests from south of the border spoke fluent English.

Prior to the conference a dozen members of the Foundation staff embarked on a ten-week study course in conversational Spanish under the direction of a special tutor. Four weeks were sufficient to convince the group that the experiment was not an overwhelming success.

* * *

In addition to Chairman Frank Hecht, the group of Chicago business-men who comprised the Sponsoring Hosts Committee were:

Hon. Emilio Almada, Acting Consul General of Mexico

Mr. Edward E. Brown, President, First National Bank of Chicago

Mr. Rolly M. Cain, Executive Vice-President, Abbott Laboratories

Mr. John H. Collier, President, Crane Company

Mr. David A. Crawford, President, The Pullman Company

Mr. Walter J. Cummings, Chairman of the Board, Continental Illinois National Bank & Trust Company

Mr. Charles S. Davis, President, Borg-Warner Corporation

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Mr. Albert T. Potter, President, Elgin National Watch Company

Mr. Edward L. Ryerson, Jr., Chairman of the Board and Director, Inland Steel Company

Mr. David T. Siegel, President, Ohmite Manufacturing Company

Mr. Douglas Stuart, President, Quaker Oats Company

Mr. Harold Swift, Vice-Chairman of Board and Director, Swift and Company

General Robert E. Wood, Chairman of Board, Sears, Roebuck and Company

Mr. E. B. Woolf, President, Mexican Chamber of Commerce of Chicago, Incorporated

Institute of Gas Technology

Annual Report

The Institute of Gas Technology completed its fourth year of operation on August 31, 1945. This report contains a description of the functions and aims of the Institute and presents summaries of the work of the Research Sections.

The Institute was founded to serve the Gas Industry of this country as a center for education, research, and information. Through affiliation with the Illinois Institute of Technology, young graduates in Engineering and Science work for Masters and Doctors degrees. Member companies share in the results of Institute Research, both basic and applied, and are entitled to sponsor projects of limited scope on an exclusive basis. The Library serves as a center for the dissemination of information.

SUMMARY OF YEAR'S ACTIVITIES

The fourth year of operation for the Institute of Gas Technology witnessed a major increase in Sponsored Research activities and the undertaking of extensive assignments under the Gas Production Research Program of the American Gas Association. The Educational Program of the Institute, which was virtually suspended early in 1944 as a result of changing Selective Service regulations, continued to operate on a greatly reduced level. Master's degrees were attained by two second year Fellows. Two others have recently completed the requirements for the Master's degree and one man continues to work toward the Doctorate.

Research for the Gas Industry

EDUCATION—Masters and Doctors degrees to Fellows by the Illinois Institute of Technology.

INSTITUTE RESEARCH—Basic and applied research on fundamental problems for the benefit of the membership and the Gas Industry.

SPONSORED RESEARCH — Problems of limited scope for the exclusive benefit of the member company sponsoring the work.

INFORMATION—Service to member companies and the Industry. General and technical information through the library.

In space and facilities, the Institute has undergone marked expansion during the year. A gasification laboratory has been constructed, gas storage facilities have been provided, and a small experimental coke oven has been built. A beginning was made on the setting up of a Natural Gas Laboratory.

The Library is now housed in adequate quarters, and an abstracting service has been begun. Publication of research reports was initiated, and applications have been made for a number of patents to cover the results of Institute research.

The Institute continues to attract new members, and contributions have again been made towards the general purposes of the Institute by a number of companies. The American Gas Association extended support to much of the Institute's Basic Research Program.

This report presents in detail the outstanding activities of the past year, and serves to inform the Gas Industry of the important Institute research projects which are now under way. More detailed publications of these results will be made from time to time.



Directors: John I. Yellott, former director; L. J. Willien, acting director; Commander E. S. Pettyjohn, U.S.N.R., incoming director.

MEMBERSHIP

The Institute of Gas Technology was formed to operate as an Educational Institution at the graduate level and to do research in the production, distribution, and utilization of natural and manufactured gas and their by-products. The basic financial support of the Institute comes from membership contracts, by which gas utility companies and appliance manufacturers undertake to support the general purposes of the Institute by moderate annual payments.

The total number of member companies is now 64, and a number of additional applications for membership are pending. It is this membership support which distinguishes the Institute of Gas Technology from other educational and research institutions and which makes it possible for the Institute to devote its activities entirely to the Gas Industry. The member companies represent, in large measure, the leading companies of the Industry throughout the entire nation.

The annual income from membership contracts for the current year will approach $70,000. Contributions from companies in the Gas Industry form an important source of income to the Institute. Approximately $11,000 was received from this source during the fiscal year ending August 31, 1945.

In order to guarantee that the Institute will be able to carry out adequately the objectives for which it was founded, increased membership support is needed. It is estimated that a firm income of $100,000 per year from membership dues will enable the Institute to carry out its program of education and basic research on an adequate basis.

FINANCIAL STATUS

The operations of the Institute were on a scale about fifty percent greater than the previous year, with a budget of about $350,000. A little less than a fifth of this was received from membership dues. About a quarter came from the A.G.A. in connection with the cooperatively sponsored basic research projects. Projects sponsored by individual companies and by groups accounted for the major part of the balance of income.

In future years, it is to be anticipated that substantial support will again be forthcoming from the American Gas Association and that member companies will continue to sponsor research on their own problems on a large scale. The Institute will carry out fundamental studies using such funds as may be available, and, when the Educational Program is restored, extensive use of the services of its graduate students will enable additional basic research to be undertaken.

It should be pointed out that the Gas Industry now has at its disposal a research institution which, at the end of its fourth year of existence, ranks among the leaders in the United States in the magnitude of its operations and in facilities for carrying out research work with competent personnel. It is particularly interesting to note that private enterprise has been responsible for virtually all of the Institute's support.

THE STAFF OF THE INSTITUTE

The Institute has, during the past year, added a number of competent research men who have made possible the undertaking of the expanded program of research. Every effort is being made to develop a staff of men and women who not only have the ability to carry out systematic research, but who also enjoy the added degree of inspiration which is needed to make original contributions.

Mr. Leon J. Willien, widely known in the Manufactured Gas Industry, joined the Institute's staff as Associate Director in July of 1944. He has been in charge of gasification research work and has supervised the work done for the American Gas Association. In addition, he acted on behalf of the Institute in a consulting capacity for several member companies.

The three major divisions of the Institute are devoted to Education, Research and Development, and the Library. The Educational Program, largely suspended during the year, was under the direct supervision of Mr. Yellott. Research and Development has been jointly directed by Mr. Willien and Mr. Yellott, while the Library and its related activities have been supervised by Mr. Creelman.

Close cooperation with the Armour Research Foundation (A. R.F.) is maintained, since the proximity of the facilities and personnel of this outstanding research organization is a great

MEMBER COMPANIES OF THE INSTITUTE OF GAS TECHNOLOGY

September 1, 1945

Amarillo Gas Co.
American Meter Co.
American Stove Co.
American Thermometer Co.
Anderson Stove Co.
Atlanta Gas Light Co.
Autogas Co.
Bastian-Morley Co., Inc.
Blaw-Knox Co.
Boston Consolidated Gas Co.
Bridgeport Gas Light Co.
Brooklyn Union Gas Co.
The Bryant Heater Co.
Cambridge Gas Light Co.
Central Hudson Gas and Electric Corp.
Cheney Bigelow Wire Works
Coast Counties Gas and Electric Co.
Colorado Interstate Gas Co.
Columbia Engineering Corp.
Columbian Carbon Co.
Connelly Iron Sponge and Governor Co.
Consolidated Gas Electric Light and Power Co. of Baltimore
Continental Carbon Co.
Cribben and Sexton Co.
The Derby Gas and Electric Co.
Dresser Industries
The East Ohio Gas Co.
Globe-American Corp.
Grayson Heat Control
Hanlon Buchanan Inc.
Hartford Gas Co.
Hope Natural Gas Co.
Hope Producing Co.
Houston Natural Gas Co.
Inland Steel Co.
Interstate Natural Gas Co.
The M. W. Kellogg Co.
Lone Star Gas Co.
Michigan Consolidated Gas Co.
Mills Industries, Inc.
Minneapolis Gas Light Co.
Mississippi River Fuel Corp.
New Bedford Gas and Edison Light Co.
Ohio Gas Light and Coke Co.
O'Keefe & Merritt Co.
Pacific Lighting Corp.
The Peoples Natural Gas Co.
Pittsburgh Equitable Meter Co.
Portland Gas and Coke Co.
Robertshaw Thermostat Co.
Rochester Gas and Electric Co.
Geo. D. Ropper Corp.
Seattle Gas Co.
Servel, Inc.
Southern California Gas Co.
Standard Gas Equipment Corp.
Surface Combustion Corp.
The Titan Valve and Mfr. Co.
United Cities Utilities Co.
United Gas Pipe Line Co.
Washington Gas Light Co.
West Texas Gas Co.
Wisconsin Public Service Corp.
Worcester Gas Light Co.

asset to I.G.T. Much of the more complicated shop work required by the Gas Institute is now being done in the well-equipped shops of A.R.F. Conversely, A.R.F. frequently finds it desirable to make use of the Library and the gas analysis facilities of I.G.T.

An active safety program has been maintained during the year, and an excellent safety record has been established. Mr. E. C. Woodward, Director of Safety for Illinois Tech, has also supervised the safety activities of I.G.T.

Regular weekly meetings of the senior staff members are held on Friday mornings, at which the developments of the preceding week are discussed, and operating problems of general interest are considered. Regular reports of the progress of particular research projects are made, so that each Section Supervisor may benefit from the advice and suggestions of his colleagues.

Staff members have taken an active part in professional societies, both in the Chicago area and on a national basis. Membership in appropriate committees of the American Gas Association has been undertaken by several senior staff members.

The Institute has rendered consulting services to a number of member companies during the past year. The interest in this service is growing, and, as the Institute attracts competent scientists to its staff, it is to be expected that member companies will make increasing requests for services of this type. Mr. Willien has been particularly active in consulting work and has devoted considerable time to the witnessing of tests on a new type of carbonization process for a member company in the East. Mr. Miller acted as a consultant for member companies in connection with rate matters, as well as in gas transmission and production problems. Mr. Yellott continued to direct the War Training Program of Illinois Institute of Technology and served as a consultant on several secret war projects.

Several members of the staff have been assigned to A.G.A. committees. The newly formed By-Product Coke Institute will also have I.G.T. representatives on three of its committees.

SPACE AND FACILITIES

The laboratories and offices of the Gas Institute are located on the campus of I.I.T. in a single-story fire-proof building on the corner of 33rd and State Streets. With the expansion of the research program during the year, additional office and laboratory space was needed. Through the cooperation of A.R.F. and I.I.T., an adequate amount of additional laboratory space was made available for important new projects, supplementing the new Coal and Gasification Laboratory which was completed during the winter. The Mechanical Engineering Department of Illinois Tech has provided temporary quarters on the top floor of Machinery Hall for the work on the Flash Pulverizer.

A Natural Gas Laboratory has been planned for location in space made available through the Peoples Gas, Light and Coke Company at their 96th Street Station. At this location, the Institute will be able to establish a laboratory where work on natural gas can be carried out on a large scale. In addition, coke-oven gas and standard Chicago mixed gas are also available. Work at 96th Street was not started during the year, because of more pressing need for the available research funds in other phases of the Institute's program. It is contemplated, however, that the 96th Street Laboratory will get under way during the coming year.

In summarizing the space situation at the Institute, it should be pointed out that the goal of a new building in the postwar period must be kept in mind. The Educational Program of the Institute is of vital importance to the industry, and so rapidly has the Research Program expanded that new facilities must be found for the necessary Educational laboratories.

The laboratory equipment of the Institute has been considerably expanded during the past year. A wide variety of instruments has been acquired, and the research sections are now reasonably well equipped with the tools which they need. The proximity of the Armour Research Foundation, with its wide range of equipment, and Illinois Institute of Technology, with its electron microscope and spectroscope equipment, enables the Institute to undertake with confidence a very wide range of projects which require exceptional scientific facilities.

During the coming year, an effort will be made to improve the equipment situation still further through the acquisition of improved gas analysis apparatus and other necessary but expensive items.

THE EDUCATIONAL PROGRAM

The formal Educational Program of the Institute was suspended in February of 1944, when further draft deferments for graduate students were eliminated. However, a number of the second year men remained at the Institute while awaiting naval commissions and were thus able to complete the requirements for the degree of Master of Science.



Students in 1943 addressed by R. B. Harper, the late director of research of Peoples Gas Light and Coke Company and secretary of I.G.T.

The Educational Program of the Institute will, it is hoped, be resumed in September of 1946. It is expected that the research work of future Fellows will form a valuable asset to the industry, since much work can be done by Fellows on projects which are not of sufficiently great immediate economic value to justify large expenditure of the Institute's funds.

The Educational Program of the Institute of Gas Technology also includes the professional advancement of its staff members. Many of the research personnel have taken courses at Illinois Institute of Technology. Several members of the staff are working towards their Master's degree and one Fellow, Mr. Henry Robison, who is employed regularly upon an important research project, is on his way to the Doctorate, having successfully passed the oral examinations. Several members of the Institute's staff have also acted as part-time instructors at Illinois Institute of Technology.

The Institute is making the necessary preparations to resume its Educational Program in 1946. During the coming year, careful study will be given to the curriculum, so that the best possible use will be made of the time of the Fellows. Contact has been maintained with most of the former Fellows, and many have expressed their intention of returning when they are released from the armed services.

THE LIBRARY

One of the principal objectives for which the Institute was founded was to provide facilities for collecting and disseminating technical information concerning the Gas Industry. To accomplish this purpose, a Library was established. It has grown steadily during the past four years and in the past year, through the cooperation of the Armour Research Foundation, has acquired additional space and improved facilities so that it is more adequate for the needs of the Institute and, ultimately, of the Industry.

The Library is one of the most important divisions of the Institute. It is through the Library that the Research Staff is kept in touch with current developments in the field of their interests, as well as with work done in the past by other investigators. The importance of an adequate literature survey prior to initial experimental work cannot be over-emphasized. Accordingly, the Library is endeavoring to provide the original source material supplied by those periodicals which are particularly devoted to the Gas Industry, and, through interlibrary loans, to secure any other publication which may be needed by the research staff.



Barbara Hopkins, Librarian.

The Library now contains approximately 5,000 volumes, of which about half are bound volumes of scientific journals which are in demand by the research staff. To this collection, some 700 volumes are being added each year. One hundred fifty periodicals are being received currently, including most of the important foreign publications related to Gas Technology. Eight of the ten German journals have been received on microfilm.

Much of the important work in the field of chemical technology is first reported in the form of patents. The Institute has a complete collection of the Official Gazette of the United States Patent Office from 1917 to the present time. By careful study of the weekly issues of the Official Gazette, the Institute is kept up to date on new inventions. A file is maintained of patents which are of particular importance to the Gas Industry.

The publication of GAS ABSTRACTS has added a new phase of service by I.G.T. to the Gas Industry, the dissemination of information. GAS ABSTRACTS, which is published monthly, consists of abstracts of papers appearing in current technical journals in the field of gas technology and related subjects. An abstracting system which was started early in the year for the mutual benefit of the members of the technical staff proved so useful that it seemed desirable to make it available to member companies. The reception given GAS ABSTRACTS amply justifies this effort.

Articles, papers and books pertaining to the manufacture, distribution or utilization of natural and manufactured gas are considered for abstracting. Only abstracts of those articles which are of immediate interest to the Institute, with a consideration of the interests of research and development men in the industry as a whole, are included. For the most part the abstracting is done by the research staff of the Institute. It is intended, in general, that the abstracts supply the technical man with sufficient information about the data contained in the paper to enable him to determine the desirability of reading the entire paper.

Barbara Hopkins, Librarian, is on a leave of absence to work with the Army Library Service in Europe. In her absence Ruth Emerson will be the Librarian. Mrs. Ruth Goodrick is now Technical Librarian, being responsible for conducting searches and literature surveys and for the publication of GAS ABSTRACTS.

Members of the technical staff are available for translating any important language. Translations from Russian, German, Japanese, French, Italian, and the Scandinavian languages can be made when it is necessary to do so.

With present Library facilities and staff, an adequate information center is now available to the Gas Industry.

LITERATURE STUDIES FOR THE AMERICAN GAS ASSOCIATION

It was realized by the Institute and by the American Gas Association that comprehensive literature surveys were an essential part of any research program for the Industry. Accordingly, the Institute was commissioned by the Technical Cooperating Subcommittee of the Post-War Planning Committee of A.G.A. to prepare four literature surveys.

These surveys were undertaken on a cooperative basis. These studies were appropriately designated as Cooperatively Sponsored Projects. Under the supervision of Mr. L. J. Willien, Associate Director of the Institute, the reports listed below have been prepared, and submitted to the Cooperating Committee, which is headed by Mr. Lee Robey of the Washington Gas Light Company.

Modern Gas Production Processes—Project CS-10

This extremely comprehensive report covers more than 200 pages and includes descriptions as well as operating results and cost analyses, when sufficient information was available, of every important gas generation process which could be located in the literature. The modern German processes which have received so much publicity are described and analyzed, and particular attention is paid to processes, either proposed or in actual use, for the gasification of low grade solid fuels.

Divided into three parts, the report in Part I(A), describes and analyzes foreign processes for the gasification of solid fuels used on commercial scale. Extensive translations of foreign publications were made for this section. Part I(B), consists of a survey of foreign processes on subcommercial scale, gasification methods in the pilot plant stage or reported in the patent literature. Part II contains descriptions of proposed American processes, including the U. S. Bureau of Mines' Parry process and two processes suggested by the Institute of Gas Technology and designated as Flash Gasification and Fluidized Gasification. Part III deals with other gas production possibilities proposed by the Institute of Gas Technology and others. It includes a detailed analysis of the problem of upgrading industrial gases in order to increase their heating value, and of the use of oxygen in water gas generators. The major part of this report has been prepared by Dr. J. J. Sebastion. Certain sections were prepared by Messrs. Willien, Singh, Stopowy, Inatomi, and Walsh.

Use of LP-Condensates—Project CS-11

In this report the probable availability of liquefied petroleum gases (LP-gas) in the postwar period has been carefully analyzed. The utilization of natural gas condensates by means of central plant distribution was next considered. It is apparent that many small isolated communities will use this method of supplying gas in the postwar period for domestic purposes. The use of gas-air mixtures for supplementing manufactured or natural gas in peak-load requirements is discussed, and outstanding examples are described.

One of the most promising methods of obtaining necessary peak-load capacity for postwar expansion of the industry is the catalytic gasification of LP-gases and higher hydrocarbons. Section IV of the report presents an analysis of current processes, originally developed for hydrogen production, by which propane and butane can be converted to an interchangeable gas.

As a result of this study, two research projects were recommended and assigned to the Institute by the Gas Production Research Committee of A.G.A.

Off-Peak Utilization — Project CS-12

An analysis has been made of possible ways of using off-peak gas production capacity. The production of synthesis gas, a raw material for the production of chemicals, has been considered, but the economics are not promising. Other possible ways of utilizing gas production capacity during summer months are considered. It is concluded that any such use must be low in first cost, in order to present encouraging possibilities.

Present Status of the Fischer-Tropsch Process and the Hydrogenation of Coal — Project CS-13

This report includes a brief statement of the Fischer-Tropsch Process, prepared by Mr. Willien, and a more detailed presentation prepared by Drs. Komarewsky and Riesz and Miss Frances Estes of the Catalysis Section. It is recognized that liquid hydrocarbons can be produced from carbon monoxide and hydrogen mixtures which can readily be obtained from either manufactured or natural gas. However, at the present time, the economics of the process are not encouraging.

A review of the hydrogenation of coal was prepared by Mr. Willien and Dr. Sebastian. The Bergius process of producing liquid hydrocarbons is reviewed. Considerable interest is expressed in gas hydrogenation processes which have been investigated in England by the Fuel Research Board, and in the United States by Purdue University.

The Gas Production Research Committee of the American Gas Association

As a result of these literature studies, the Institute prepared a statement of its research policy entitled "A Program of Research for the Manufactured Gas Industry". In this statement, which was prepared with the assistance of the late Mr. Henry Loebell, an eight point program was recommended to cover both the immediate and long range needs of the Industry. Specific proposals for well-defined research projects were prepared to implement the general recommendations.

The Gas Production Research Committee of the AGA, under the chairmanship of Mr. P. T. Dashiell, visited the Institute on December 19, 1944. A report on the current research work at the Institute was presented with a series of eight specific proposals. The Gas Production Research Committee, at subsequent meetings, has approved most of these original proposals.

Thus the Gas Production Research Program, which was originally contemplated by the Institute in the Spring of 1944, is now receiving large scale support from the American Gas Association. Thanks to this support, the work is being pushed vigorously, and there is every confidence that significant results will be obtained. The reports of this work will first be submitted to the Gas Production Research Committee, and, as this Committee authorizes their publication, the results will be made known to the Institute's members, and then to the industry as a whole.

RESEARCH AND DEVELOPMENT

Two major fields of activity are included in the research program of the Institute. The first of these is Institute research. It was contemplated by the founders of I.G.T. that work on broad and general problems, of interest to the entire industry, would be undertaken by the Institute as a

primary responsibility. It was expected that some phases of this general field of research would be accomplished through use of graduate students, but that most of it would be done by the full-time research staff.

From a relatively small beginning, the program of Institute Research has expanded vigorously, and, thanks to the support of the Gas Production Research Committee of the American Gas Association, the Institute is now going ahead on a broad and comprehensive program of essential projects.

Equal in importance to the Institute research program is sponsored research, undertaken at the request of individual member companies. Sponsored research during the past year has reached a new high point, and twenty-two such projects have been active during the year, with a total estimated cost of $160,000. In addition, with the approval of the Board of Trustees, important work was undertaken for the National Research Council and for the Illinois Coal Products Commission. Sponsored research projects cannot usually be publicized, but a few such projects, because of particular circumstances, will be mentioned in a later portion of this section of the report where the activities of each Research Section will be discussed.

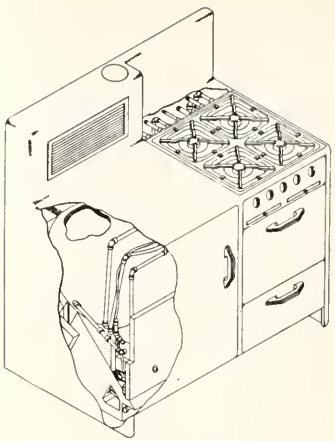
The Research Staff of I.G.T. is divided into eight parts under the direction of eight Section Supervisors. The following detailed description of research activities is sub-divided under the sections responsible for the work.

Appliances

Mr. M. Frank Knoy, *Supervisor*

The Appliances Section has been extremely busy with nine sponsored projects in progress during the year. The major project, and the only one which may be described, is the Three Service Range development, sponsored by a group of New England utilities and seven range manufacturers.

The Three Service Range was intended to provide a 20-gallon automatic storage water heater, a 25,000 Btu forced air heater, and the usual oven and top cooking facilities. All of these services were to be supplied in a standard range, 42 inches in length, 25 to 28 inches in depth, and 36 inches from the floor to the working surface. After several preliminary problems had been investigated and the Steering Committee had decided upon the final form of the range, a successful model was built and demonstrated in Boston, in April. An illustration of the range indicates that the compactness required by the unusual conditions has been attained. The test model delivered the necessary performance without difficulty.



The three service range.

The Sponsoring Committee for the Three Service Range has arranged with a manufacturer to build the water heater and the air heater. It is planned that the range will be placed in production early in the postwar period. It should fill a real need, not only in the New England market, but in other areas where the convenience of automatic water heating is appreciated and the desirability of a moderate amount of space heating also exists. It should be particularly suitable for users of LP-gas in isolated locations.

In general, it can be stated that the Appliance Section of the Institute rendered service during the year to manufacturers whose own research and development staffs were not in a position to handle these projects themselves. Several of the projects required particular equipment, or shop facilities available at the Institute. It is to be anticipated similar projects will continue in the future. In addition, it is hoped that fundamental research in the application of gas for domestic and industrial purposes can be undertaken.

Catalysis

Dr. C. H. Riesz, *Supervisor*
Dr. V. I. Komarewsky, *Consultant*

The Catalysis Section has carried on projects in the Fischer-Tropsch process, and in the utilization of propane. In addition, much of the literature study for Project CS-13 was carried out by the section. As a result of the recommendations made to the Gas Production Research Committee, the Catalysis Section has undertaken a laboratory study of the catalytic gasification of higher hydrocarbons.

Utilization of Propane

Investigation of high grade utilization of propane has a long range view-point. Processes which are usable for propane will ultimately find application for natural gas. Therefore this work is a starting point for effective utilization of natural gas.

An investigation has been directed toward the up-grading of propane by means of a catalytic reaction under high pressure. Preliminary work has been started at moderate pressures, and high pressure equipment is under construction.

Synthesis of Valuable Products from Carbon Monoxide and Hydrogen

The commercial production of motor fuel from natural gas by means of the Fischer-Tropsch process may become feasible in the near future. The more important petroleum laboratories, the Bureau of Mines, and others are actively pursuing various phases of this subject. The natural gas industry, therefore, has an immediate interest in this subject while a long-term viewpoint should be maintained by the manufactured gas interests.

Hence this project has been established as a basic project at the Institute of Gas Technology. Obviously the program of work cannot be as extensive as those which have been mentioned. Therefore the plan of attack is to maintain a continuing survey on Fischer-Tropsch developments and related subjects, and to study the action of catalysts from a scientific viewpoint with the ultimate aim of gas industry applications. A paper* was presented before the Gas and Fuel Division

*Petroleum Refiner, November, 1944, pp. 415-422.

of the American Chemical Society last Fall which reviewed important aspects of the published literature and presented objectives for gas industry research in detail.

Work on Project CPR-1B, Catalytic Gasification of Higher Hydrocarbons, began in January, and progress reports are being submitted regularly to the Gas Production Research Committee. Encouraging results are being obtained, and it appears that there is a reasonable chance of reaching the goal of gasification with steam and catalysts of hydrocarbons as heavy as kerosene or gas oil, using relatively simple equipment.

Chemistry

Dr. S. W. Martin, *Supervisor*

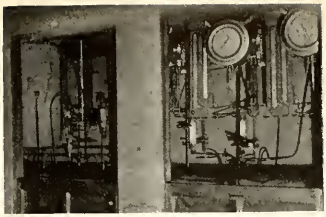
The outstanding project of the Chemistry Section has been the Organic Sulfur Project, CS-1, 2, which has been jointly supported by the Gas Conditioning Committee of the American Gas Association, by the Rochester Gas and Electric Company, and by the Gas Institute. The analytical phase of the Project has resulted in the development of procedures for the quantitative determination of sulfur compounds in manufactured gases.

The method of analysis is based on total sulfur differences resulting from the combustion of the gas before and after treatment with selective absorbents. Effluent gases from the burner are scrubbed with a sodium peroxide solution, which is then analyzed gravimetrically by means of an improved barium sulfate procedure. Refinements introduced by Institute research have made this method reliable even in the low range of organic sulfur concentration encountered in many commercial gases. The apparatus evolved for obtaining both the total sulfur and specific groups of organic sulfur compounds is shown diagrammatically in the drawing.

At present, the analysis includes sulfur compounds listed as follows:

(1) Hydrogen sulfide and mercaptan sulfur
(2) Thiophene sulfur
(3) Carbon disulfide and carbon oxysulfide sulfur
(4) Residual sulfur compounds

Hydrogen sulfide and mercaptans, if present in appreciable concentrations, may be determined



Experimental testing of Fischer-Tropsch catalysts.

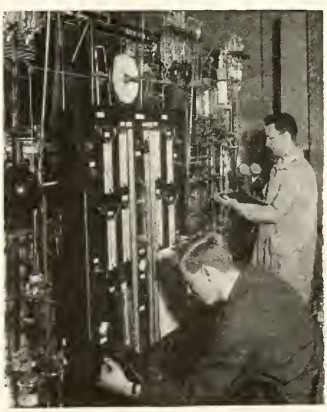
by total sulfur differences resulting from scrubbing the gas sample with an alkaline cadmium chloride absorbent. Ordinarily manufactured gas distributed for consumer use contains only traces of hydrogen sulfide and mercaptan sulfur. As a result, the very accurate and sensitive iodometric titration of the cadmium chloride reagent is employed to specify this group of sulfur compounds. The remaining groups of sulfur compounds are determined by total sulfur difference procedures.

To illustrate results obtainable, the following analysis of a manufactured gas is included.

Organic Sulfur Analysis

Sulfur Components	Concentration grains of sulfur per 100 cu ft of gas
Ethylmercaptain + 2 hydrogen sulfide	0.08
Thiophene	0.86
Carbon disulfide + carbon oxysulfide	6.95
Residual sulfur	0.21
Total sulfur	8.10

Present research is directed toward additional refinements and simplifications in experimental techniques as well as an evaluation of possible interfering substances in manufactured gases.



Organic Sulfur Research

Another aspect of organic sulfur under investigation is the development of fundamental information regarding a liquid absorption process for sulfur removal. Physical chemical research is now in progress to make available equilibrium data for the reactions involved in the removal of carbon disulfide and carbon oxysulfide by means of organic liquids. A study of reaction conditions and especially of possible interfering factors is now under way.

The Chemistry Section also studied the sulfur content in liquefied petroleum gas for a prominent eastern distributor. It was found that corrosion in gas lines was being caused by an excessive concentration of organic sulfur in the gas, and suggestions were submitted for remedying this condition.

Because of Dr. Martin's experience in the field of pigments several projects have been under way during the year related to the production of carbon black, one of the most essential requirements of the synthetic rubber program. The projects are on a sponsored basis, and accordingly it is not appropriate to divulge the names of the sponsors or the details of the projects. However, it should be stated that, thanks to the electron microscope, carbon black research can be undertaken with confidence by the Institute.

The Physics Department of IIT has assisted greatly in the efficient and rapid solution of several difficult problems by making their electron microscope available. The use of the electron microscope for I.G.T. projects is another example of the cooperation given by I.I.T. and A.R.F.

Chemical Engineering

Dr. Joseph D. Parent, *Supervisor*

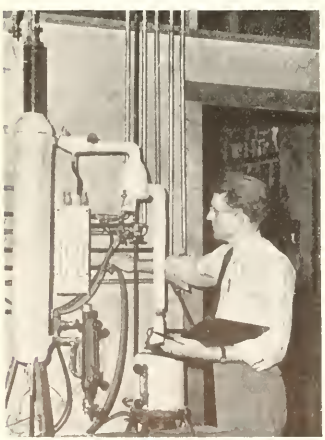
The major basic project in this section was a fundamental study of fluidization. This research work had as its aims the observation of the characteristics of fluidized systems and their evaluation.

Perhaps the most interesting finding is that the bubbling of a gas up through a smoothly fluidized bed is attended by a pressure loss that is exactly the same as would be expected in a liquid of the same mass and density. Even for linear velocities as high as 1½ ft. per sec. the pressure drop,

exclusive of wall effects, is invariably equal to or very slightly greater than the suspension head which is being overcome. This principle holds true no matter what solid, gas, apparatus, or operating conditions may be used. This principle is doubly interesting since not only is the loss in head chargeable to the bed constant and predictable, but the amount of material inside a vessel with opaque walls can be easily determined.

Three types of behavior are observed when attempts are made to fluidize a bed of solids: mechanically smooth fluidization, channeling, and slugging. The first type is obtained when a proper size or mixture thereof has been used, and it is characterized by a rather quiet action with particles moving along twisting, ever-changing paths which are primarily upward in the central part of the vessel and downward along the walls. The second type is obtained when a material is too fine or lacks a sufficient proportion of coarse particles. The third type has been observed for systems of particles which are too coarse or lack a sufficient proportion of fines, and it is characterized by an action similar to that of the bumping of boiling liquids. In small diameter tubes, such a system slugs or forms pistons of material which rise along the walls and slowly break.

Bed height and container diameter have an influence on the behavior of a system. An increased bed height usually enhances any tendency toward slugging, whereas a decrease in vessel diameter usually increases any tendency toward channeling.



Heat Transfer to Fluidized Solids

Only a meager amount of information has been obtained on heat transfer. The overall heat transfer coefficient from condensing steam in an annular space at atmospheric pressure through a copper tube two inches in diameter to nitrogen gas at an average linear superficial velocity of 0.4 ft. per sec. was a 3 percent lower when 70/325 mesh coke was present in the central tube than when it was absent. The rate was 5 percent higher when the velocity was 0.5 ft. per sec. It seems probable that the presence of fluidized solids in a gas stream has no great influence on heat transfer rates.

Many other interesting features have been observed, such as that samples of a given material can be fluidized even when their average particle sizes differ widely as long as a reasonable distribution of sizes is present.

Most of the small scale work that is necessary has been completed. Experiments with larger scale equipment are being planned.

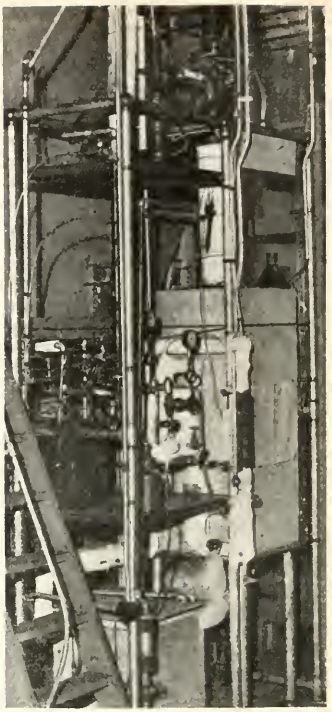
In addition, a sponsored project has been active during the year, in which the Flash Pulverizer and fluidization are being applied to an important chemical engineering production process by Dr. Parent and Mr. Alexis Rudnitski.

An important project was undertaken for the National Research Council, the details of which are restricted. It must suffice to say that Dr. Parent and Dr. Sidney Katz have learned how to prolong the life of an essential military item by at least 200 times, through relatively simple changes in construction. This project is continuing.

Catalytic Gasification

Dr. J. J. S. Sebastian, *Supervisor*

The gasification of coal and other carbonaceous materials is obviously of tremendous importance to the Gas Industry. In this section of the Institute, a number of projects have been under way during the past year, some of which are now being carried on under the Gas Production Research Program of the American Gas Association. Attention will first be turned to the work of Dr. Sebastian who has been assisted during the year by Mr. Claus Von Fredersdorff, Mr. Ray Gardner, and Mr. Witold Stopowy. The major assignments given to Dr. Sebastian were the carrying on of research in continuous and complete gasification by the fluidization process, and the preparation of a major part of the literature survey and critical evaluation of modern gas production processes.



Fluidized Gasification

Fluidized Gasification

This project has for its objective the study of the complete gasification of pulverized solid fuels by means of decomposing steam in a "fluidized" solid fuel bed. While the broad objective is the low-cost production of a high heating value gas from low grade coals, the accomplishment of which will probably require the use of superatmospheric pressures, the goal set at present is the production of blue gas at a low cost, both in regard to investment and operation. It is expected that, because of the extremely large surface available for reaction through fluidization of pulverized fuels, the overall rate of reaction between carbon and steam on one hand, and be-

tween carbon and hydrogen on the other hand, will be increased, and thus a faster rate of gasification may take place at a lower temperature than the conventional 1800°-1900° F.

A 4 inch I.D., 7 ft. long metallic generator has been constructed for the purpose of blue gas production by passing steam superheated above 900° F through a "fluidized" bed of powdered coke at 1 atmosphere or slightly higher pressures. The immediate goal has been to set up complete heat and material balances for the systematic study of the gasification of variously sized fuels at temperatures as far below 1800° F as the reaction rate will permit.

A pyrex glass fluidizer, of 4 in. I.D. and 5 ft. long, has also been constructed for the purpose of studying the fluidization characteristics of various fuels up to 1000° F at 1 atmosphere pressure. The parts of this apparatus are essentially the same as those of the metallic generator, except that some of them are on a smaller scale. Since the reactor itself is made of glass, the effect of such variables as size distribution, linear velocity and nature of the fluidizing medium, temperatures up to 1000° F, and dimensions of the reactor, can thus conveniently be observed and evaluated.

The evaluation of the results indicates that the study of the variables in the process can well be directed toward the immediate goal of improving both the quality of the gas produced and the operating efficiency.

Coal and Gasification

Mr. A. D. Singh, *Supervisor*

The Coal and Gasification Section has carried on a number of projects in the development of new methods of coal carbonization, gasification, and pulverization.

Flash Pulverizer

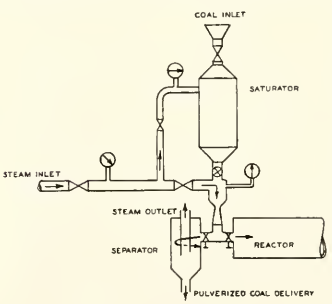
Of primary importance has been further work on the development and application of the Flash Pulverizer. This development is an exclusive product of the fundamental research program of the Gas Institute. It resulted directly from the realization that a better method of pulverization was vitally needed if the continuous gasification of pulverized fuel were to be an economical and efficient means of producing gas.

The pulverizing of minerals is a matter of tremendous importance in engineering technology. This is particularly true in the field of coal pulverization, since most modern large steam generating equipment is fired with powdered coal. Study of the art of pulverization reveals that, in addition to the various types of mechanical mills which have been used for this purpose, there have been many other types of equipment developed or suggested to bring about decrease in particle size and a consequent increase in effective surface of materials.

One notable example is the type of device in which the material to be pulverized is given a high velocity by introducing it into a rapidly moving stream of air, and causing it to impinge upon a target, thus bringing about some degree of pulverization. Another well known device in this field is the "Micronizer", which causes pulverization by attrition among particles which are rotating at high speed in a fluid vortex.

Many years ago it was discovered that certain materials could be disintegrated to some extent by causing them to be saturated with a high pressure gas, and then releasing that pressure as rapidly as possible. Among these developments are the well known varieties of cereals, and the shredded wood products which are used to make wall board. Additional work in this field has been reported by the Bureau of Mines where explosion pulverization of ore was investigated several years ago.

Fundamentally, the pulverizer is an advance in the art of explosion pulverization, which until this time has been limited to the production of puffed cereals and a few other materials. The Flash Pulverizer is the first adaptation of this principle to the continuous pulverization of minerals.



Flash Pulverization

Flash Gasification

Flash gasification of liquid and solid fuels was proposed more than a year ago, and work has been carried on to test the feasibility of this process. This project is receiving further support from the Gas Production Research Committee of the American Gas Association.

The purpose of this research is to develop a process for the complete gasification of both liquid and solid fuels and to produce a high Btu manufactured gas. The investigation will first cover the gasification of liquid fuels, and subsequently the gasification of pulverized solid fuels.

Dr. R. Leonard Hasche of Tennessee Eastman Corp. reported the results of a series of cracking tests on natural gasoline and propane at temperatures of 1472° F to 2417° F at a 0.1 second or less time of contact in an atmosphere of steam. (Chemical and Metallurgical Engineering, July, 1942.) These data are promising enough to indicate that complete, controlled gasification can be obtained through short contact times as well as through a recycle of any partially cracked materials. The short contact time would make for smaller and more economical equipment for the production of a given amount of gas.

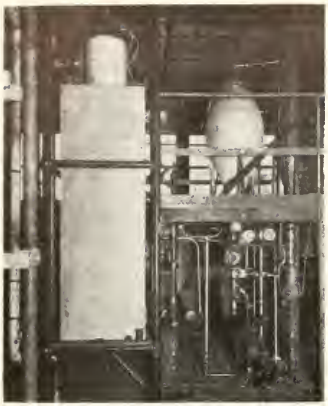
Following a literature survey on the gasification of solid fuels and a review of the more recent developments in petroleum cracking, the design of an experimental unit was begun last year. This unit has now been built and is currently operating on liquid fuels. Preliminary operations were started on a "gas oil".

The future program is intended to cover the general outline given below:

1. Correlation of the variables of temperature, contact time, steam to oil ratio, degree of cracking, etc. with the amount and heating value of the gas produced from various grades of liquid fuels. Simultaneously with this work, the rate of carbon deposition and the rate of corrosion of the cracking tubes will be studied.

2. A study of the effect of recycling tars and partially cracked oils will be conducted.

The gasification of solid pulverized fuels will then form the basis



Coal Carbonizing Unit

for the remainder of the investigation. In general the same variables will be studied as for the liquid fuels.

Coal Carbonizing

One of the major contributions of the Institute has been the development of a continuous process of devolatilizing coals, such as those which Illinois produces, which are high in volatile content. A project was originally sponsored by a member company, in which the fluidization process was found to be adaptable to devolatilization. By producing a low volatile char, and blending it with the original coal, a superior high temperature coke was produced. Metallurgical rights to this project belong to the original sponsor, but the Institute has retained all other rights and has filed a patent application to cover the process. During the summer of 1944, the Illinois Coal Products Commission, created by the legislature to find improved methods of using Illinois coal, requested the Institute to undertake further development of the devolatilization process with the intention of producing coke for metallurgical and other processes from Illinois coal.

The process is now operating continuously, and char of controlled volatile content can be produced, while the resulting high heating value gases can be recovered and used in gas operations.

Project S-35, sponsored by the Illinois Coal Products Commission, has for its purpose the demonstration of the practicability of making from high volatile Illinois coal a non-smoking fuel, and a good quality metallurgical coke.

METALS AND REFRACTORIES
DR. V. DE MARCHI, *Supervisor*

The Metallurgical Section has been engaged for the past two years exclusively on a major project in which gas technology is applied to an industrial application of vast potential importance. This project like most other sponsored projects is confidential, and, until adequate patent protection has been obtained for the sponsor, it is not appropriate to reveal any details. However, it should be stated that Dr. V. S. de Marchi, assisted by Mr. Adolph Roman, Mr. Shiro Mori, Mr. Masanobu Miyaji, Mr. Charles Steiner, and Mr. Robert L. Husch, have carried a process of tremendous value along to the point where the sponsor is negotiating for the erection of a large pilot plant. This project will undoubtedly continue for some time to come, and, when the details can be revealed, a major advance in gas technology will be disclosed.

THERMODYNAMICS
DR. E. F. LYPE, *Supervisor*

Dr. Lype joined the Institute in the summer of 1944. His activities have been directed toward problems of thermodynamics and kinetic theory arising from sponsored and basic research projects. A comprehensive report on the Entrainment of Air by Gas Streams has been prepared for a member company, in cooperation with the Appliance Section.

A major project undertaken by Dr. Lype, with the assistance of Mr. Morris Friedman, is the tabulation of the properties of high temperature steam. This project, B-100-H, is an essential part of I.G.T.'s comprehensive Gas Production Research Program. It is impossible to predict such extremely important matters as heat transfer coefficients and pressure drops in process equipment without knowledge of the properties of the fluid involved. Up to the present time, available tables of the properties of steam had no data for temperatures higher than 1600° F. Dr. Lype, while he was engaged by the Combustion Engineering Company, prepared a set of steam tables which they published. These tables also did not go above 1600° F. However, the equation of state developed by Dr. Lype was entirely adequate to carry the tables on to 2000° F, thus covering the range required by gasification processes. Tables and charts have been prepared which list the important properties of steam, and which present these properties graphically in terms of pressure and temperature.

This work has served as the basis for a paper that will be presented before the ASME in New York in November, 1945. Reprints will be available on request.

NATURAL GAS RESEARCH

Under the direction of Mr. Miller, Mr. Clinton B. Folkrod and Mr. Erwin Strong have been carrying forward the work begun by Mr. Strong in his thesis investigation of natural gas hydrates.

The Composition of Gas Hydrates

The objective of this project is the development of a process for storing natural gas in the form of gas hydrate. It has long been appreciated that the storage of natural gas is one of the most important problems facing the Industry. Natural gas is widely used for space heating, and for other services which also have the characteristic that the demand which they impose upon a natural gas system increases as the general atmospheric temperature decreases. Because of this, it has usually been necessary to install production and transmission facilities capable of meeting a tremendous demand, which exists only during short periods of extremely severe weather. Such facilities are used only in part for most of the year.

Fundamental data required for an appraisal of the economic possibilities of gas storage in the form of hydrate include such information as the composition of the hydrate in terms of the amount of water per MCF of gas, the heat which must be removed when the hydrate is formed and



The Experimental Coke Oven

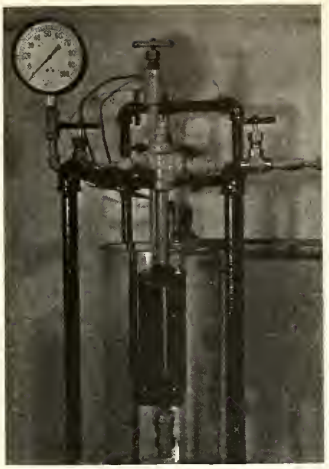
which must be added to get the gas out again, the volume of the hydrate as compared to the volume of gas from which it is formed, the pressure-temperature relationship at temperatures below the freezing point of water which might be useful for storage, and the influence of gas composition upon all of these. The program which has been projected includes the obtaining of such information. To date, only propane and ethane have been used in the laboratory work. It has been determined that propane hydrate can exist at temperatures below 42° F, approximately, and that it contains six molecules of water per molecule of propane. The work with propane was done first because propane can be handled at lower pressures than are necessary with the more volatile hydrocarbons, and it was desired to test the proposed technique with the simplest equipment which could be used. The technique which had been proved by the work with propane has also been employed with ethane.

Surveys

Certain research projects were undertaken by members of the Administrative Staff of the Institute. It was recommended to the Gas Production Research Committee that an immediate study be made of methods now in use in the petroleum and natural gas industry for producing hydrogen, since the first step of this process is the production of a carbon monoxide and hydrogen mixture. This project, CPR-1A, was authorized by the Gas Production Research Committee, and Mr. Benjamin Miller has been active in obtaining the necessary information and preparing progress reports.

The Associate Director of the Institute, Mr. L. J. Willien, was authorized by the Gas Production Research Committee to undertake Project CPR-2, A Study of Existing Gas Production Processes, with the intention of reporting to the industry at large on methods successfully employed in increasing gas production from existing equipment without extensive investment.

A comprehensive report on gas producers wes prepared by Mr. Witold Stopowy under the direction of Dr. Sebastian for the Locomotive Development Committee.



Gas Hydrate Apparatus

The foregoing reports have presented briefly the highlights of the research program of the Institute. Basic Research projects, of the magnitude of those described above, are admittedly expensive, and they could not have been undertaken by the Institute at this time without the support of the A.G.A. The contract between A.G.A. and I.G.T. calls for mutual exchange of patent rights on the cooperatively sponsored program. In this manner, the A.G.A. can support the work of the Institute, the Institute can make available appropriate basic research inventions, and the member companies of the Institute, as members of the industry at large, will immediately receive the benefits of this expanded research program.

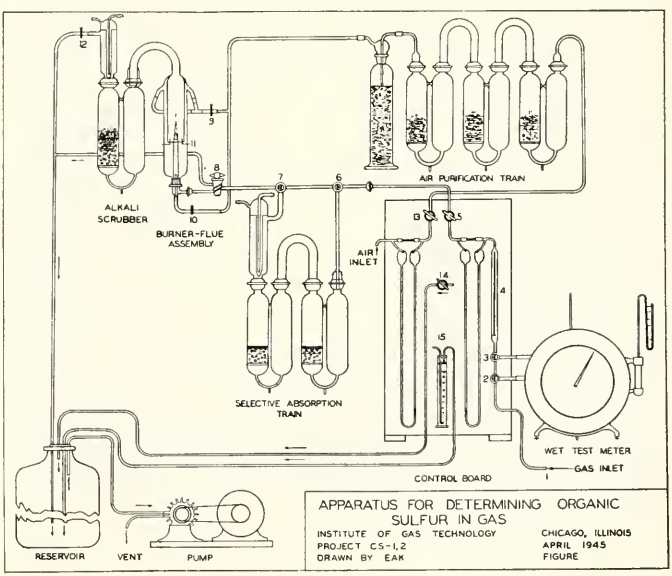
THE INSTITUTE LOOKS AHEAD

The Gas Institute has now been in operation for four years, all of them particularly difficult because of the impact of the war upon educational and research activities. Nevertheless, I.G.T. has grown until it now ranks among the first ten industrial research foundations of the country.

The Institute is being called upon to take an increasingly important part in the Gas Production Research Program of the American Gas Association, and plans are being made to undertake other research projects in natural gas and in the applications of both manufactured and natural gas, including natural gas condensates.

It is probable that the Institute will receive increasing recognition from industries related to gas production and utilization. The coal industry, both anthracite and bituminous, has already been attracted by Gas Institute developments. Work for related industries, however, will only be under-

Continued on page 42



Fire Protection Engineering

History of a Department and a Department Head

By

K. H. Parker

Biographical Sketch of Professor Joseph Bernard Finnegan Including a History of the Department of Fire Protection Engineering, Illinois Institute of Technology, Presented at Dinner to Commemorate the 40th Anniversary of his Service to the Profession of Fire Protection Engineering, Chicago, Illinois, May 28, 1945.

It is not the purpose of this biographical and historical sketch to probe our honored guest's past in order to suitably embroider the distinction and esteem in which we rightly hold him in our professional and personal relationships. There might be merit in such a purpose were this a more formal occasion, in which someone who has achieved financial, political, or social prominence needs gilding in order that he may appear worthy of the honor being accorded.

This is not our reason for gathering here tonight. The achievements of our guest's life in service to our school, profession, and fire protection education in general are so manifest to this group of men sitting here in this room that they need no repeating. But rather, we have felt that the events that led to his entrance into this profession, the origin of this unique educational movement in fire protection engineering, and a personal history of some events which he has passed through would serve to focus our thinking and bring his 40 years of service in the department of fire protection engineering into sharper perspective.

Joseph Bernard Finnegan was born in Stoneham, Massachusetts in 1880. We will pass over his childhood days other than to mention that he attended the local grammar and high school, graduating from the latter in 1899. We can deduce from that fact that he was not precocious—no genius here—no child prodigy; just as you and I, it took him 18 years to reach the limit of public school education.

At this turning point in a young man's life, there appears a first glimpse into his ability to exercise



Professor Finnegan

self-control. He decided to enter Massachusetts Institute of Technology, thus conforming to the accepted scheme of things to one born among the Brahmans of the Bay State. At the end of his Freshman year in 1900, he was forced to remain out of school one year because of trouble with his eyes, and during that time worked as a civil engineer in the sewer department of Stoneham. He returned to M.I.T. the next year, resuming his course in chemical engineering. To supplement his resources and his experience in the sewer department, he worked at numerous other odd jobs through college and spent the summer of 1903 as chemist and draftsman in the Gas Plant at Norfolk. In 1904 he was graduated from M.I.T. with the degree of B. S. in chemical engineering in a group which numbered only seven and our young engineer looked around for a salary check.

Now it happened that young Mr. Finnegan, age 23, had not even been conscious up to this time of the business of fire insurance. As a matter of fact, except for occasional engineers hired for specific duties such as waterworks engineering or sprinkler work, the fire insurance boards and bureaus were not in the habit of employing technically trained men. But it also happened that in 1904, following the great Baltimore conflagration which had focused attention on the serious nature of the conflagration hazard in many cities, the National Board's Committee of Twenty were looking for engineers with experience to make the investigations that eventually led to the present Standard Grading Schedule. They contacted many of the technical schools. Young Mr. Finnegan did not have sufficient experience but he was told that the New York Fire Insurance Exchange was looking for a number of cub engineers; and that is where he went immediately following his graduation in June of 1904.

Fourteen men were engaged at that time by the Exchange, 12 of them recent graduates of technical schools. The hiring of these young engineers for use as inspectors and raters was considered as an experiment. It had not been the practice previously. We have to remember that the idea of schedule rating was still very new in 1904 and the Universal Mercantile Schedule which was of comparatively recent origin, had not been applied extensively up to that time even in the East where it had its genesis.

The New York Fire Insurance Exchange territory covered greater New York and some of the New Jersey cities and our cub engineer started in as an inspector and rater, first undergoing a course of education and training formality set up under the auspices of E. R. Hardy, then assistant manager. Mr. Hardy is well known to all of us as the author of a number of textbooks on fire insurance schedules, and for his leadership over a period of many years in fostering and advancing insurance education.

In passing, it is more than of usual interest that in this group of men hired by the New York Fire Insurance Exchange were

two other young engineers whose names are familiar to all of us—H. E. C. Rainey, in later years assistant manager and then manager of the Underwriters Association of the District of Columbia, and Alvah Small, now president of Underwriters' Laboratories, Inc. and meeting with us as a guest this evening.

Let us leave our cub inspector in New York for a moment while we wing our way westward across the Hudson River and the Jersey flats some 1000 miles into the heart of the great Northwest Territory as it once had been known, and the Middle West as we know it today.

Chicago had developed into a great insurance center in the late 1800s. Western departments of the companies had centered in this city. The Union, later the Western Union, was the first of the major underwriting associations. But Chicago was even more unique in its having been the birthplace in 1894 of the first laboratory established to study the hazards of electrical devices and wiring. This pioneer laboratory became known as Underwriters' Laboratories, and eventually developed into the great institution it is today for the study, investigation and testing of devices and materials in relation to life, fire and casualty hazards and to prevent loss of life and property from these hazards. William H. Merrill, founder and then secretary of the Laboratories, conceived that there was a very real need for a course of engineering study especially designed to furnish graduate engineers with the requisite technical foundation and that fire protection engineering offered an excellent field for young men who wished to prepare themselves for work in one or more of the various branches of the business. He had already hired Fitzhugh Taylor, an electrical engineering graduate of Armour Institute of Technology of the class of 1900. From this contact and the fact that Armour Institute was located in the same city, the suggestion was advanced to Dr. Frank W. Gunsaulus, president of Armour Institute, that such a course be inaugurated, in cooperation with Underwriters' Laboratories which had the required special laboratory facilities available. Such then was the formation of the department of fire protection engineering.

The original intention was that the department be started in 1902. However, for some reason not entirely clear, it was not actually established until 1903 and the first group of students was made up of those who enrolled in the department as sophomores. Twelve men were interested in enrolling in the course, of which group only five completed all professional courses, and four graduated. The year 1906 was the first in which degrees of B. S. in fire protection engineering were awarded. Among these original 12 we recognize a number of familiar names: Arnold A. Hepp, manager service department of the Home Insurance Company, at Atlanta, Georgia, and older brother of Emil J. Hepp, secretary of the Springfield F. & M., a later graduate of the department; Walter S. Oberfelder, president of Walter Field Company, Chicago mail order house; Lee R. Ross, vice-president of the Phoenix Insurance Company of Hartford; Earl J. Smith, engineer, Gases and Oils, Underwriters' Laboratories, Inc.; Ray E. Swearingen, chief engineer of the Pacific Coast department of the Continental Insurance Company; and Joel R. Wilson, chief engineer, Marsh & McLennan, Inc. Two of that original class are here tonight—E. J. Smith and Joel R. Wilson.

To go back again, at the time of the establishment of the department in 1903, Fitzhugh Taylor was head of the department and its only professor, giving the laboratory courses at Underwriters' Laboratories. In 1905, the first senior class was coming up and Mr. Taylor saw a need for an additional instructor with the necessary field experience to handle the courses at the Institute. He knew of the educational work being given to young engineers at the New York Fire Insurance Exchange and so went East and asked Mr. E. S. Hardy to recom-



Students of Fire Protection Engineering are shown testing the fire extinguisher at the Underwriters' Laboratories.

mend some one of his younger engineers. Hardy recommended Joseph B. Finnegan. Young Mr. Finnegan accepted the offer of the position and so in September, 1905, a mere 40 years ago, joined the faculty of Armour Institute as instructor in fire protection engineering. The chemical engineering graduate, erstwhile fire insurance engineer, inspector and rater was embarked on his career of teacher.

The curriculum of the department had been set up by Mr. Fitzhugh Taylor in cooperation with the Institute, and in the beginning Mr. Finnegan had all the senior work except the laboratory courses. He also had the junior course of lectures in fire protection engineering and a course called insurance practices and schedule rating which covered material of the same kind as is now in the Fire Insurance Practice course. There were also two courses in the analytic system for the measurement of relative fire hazard. The first edition of the analytic system had been published by A. F. Dean in 1903 and was being adopted and applied by rating bureaus in the middle west. It was natural that the philosophy and application of the analytic system should be studied carefully by students in the department.

The department was quite small in total numbers of graduates until the establishment of the scholarship plan in 1920. In going through the records, we find only one alumnus in the class of 1907; two in 1908; four in 1909; E. W. Hotchkin, assistant U. S. manager of the Royal Insurance Co., one of two in 1910; six in 1911; Chester A. Snow, secretary, Phoenix of Hartford, was the only graduate in the Class of 1912; four in 1913 and 1914. Beginning with the Class of 1915, the number of men in the Department increased substantially until World War I interrupted the college work of those who normally would have graduated in 1919 to 1921. In these intervening years, however, demand for its graduates had increased materially and the work of this pioneer department had become well known to the fire insurance fraternity and industry, particularly in the Middle West. Running through the list we find Theodore K. Pfafflin, late manager of the Chicago Service Office of the Home Insurance Company; Walter H. Rietz, vice-president of Ilg Electric Company; Leonard Peterson, vice-president of the Home Insurance Company; W. Russell Owen, chief examiner of the National Fire Insurance Company, and many others.

To get back to Mr. Finnegan, in 1906 he was made assistant professor of fire protection engineering and also became assistant engineer in the protection department at Underwriters' Laboratories, an association that lasted for many years. On the strength of this, he returned to Stoneham and married his boyhood sweetheart, Margaret Birmingham. In 1907, he was made associate professor of fire protection engineering and continued in that capacity until 1916 when Fitzhugh Taylor resigned to give all of his time to Underwriters' Laboratories, and Professor Finnegan was made head of the department in his place.

As mentioned previously, the growth of this pioneering educational course in fire protection engineering had been watched with much interest by fire insurance circles in the Middle West and many of the graduates had been employed either by inspection or rating bureaus or by the companies, agencies or brokerage concerns. The Fire Underwriters Association of the Northwest, one of whose purposes was the advancement of standards in insurance education in this field, became interested in 1913. At their annual meeting Wellington R. Townley, president of the association, offered the recommendation that a scholarship be established by the Association at the Armour Institute of Technology in the fire protection engineering course. The Association endorsed this proposal and established a scholarship plan under which one four year scholarship was to be awarded each year. Later, Mr. Townley was chairman and member of the scholarship committee of the Association and in that capacity he actively fostered the scholarship plan.

By 1920 the original scholarship plan of the Fire Underwriters Association of the Northwest had been in operation six years during which time five awards were made. The war had resulted in great curtailment of the supply of technically trained men and there was a serious deficiency in the number and training of men available for employment as fire protection engineers and inspectors by inspection bureaus and companies. J. V. Parker, manager of the Western Actuarial Bureau, sensed the growing demand for men with this specialized engineering training. He envisioned that such highly qualified men would be of great benefit in interesting property owners in providing improved construction and protection, and that such a program could not but be of great value to the public and the fire insurance business alike. His initial explorations of the subject with company executives gave support to the plan as outlined, and R. D. Hobbs, assistant manager, was assigned to work out details. Agreement on the outline of the enlarged plan was reached with Dr. Gunsaulus, it having been decided that Armour Institute offered the best facilities for putting the plan in effect. In 1920 this initial exploration of an enlarged scholarship plan and its possibilities bore fruit in the establishment by the stock fire insurance companies of 25 scholarships each year in the department of fire protection engineering for the purpose of interesting able and energetic young men in this profession. These were full four year scholarships covering the entire tuition and fees for the four year term.

By an amendment of the by-laws passed at the annual meeting of the Fire Underwriters Association of the Northwest, the scholarship plan of the Association was merged in the broader program. William H. Merrill, whose vision had led to the formation of the department, was a member of the first scholarship committee. Wellington R. Townley served as a member from 1920 until his death in 1941, and those of us who knew him during that period will always remember how faithfully he attended the department gatherings, usually in the company of J. V. Parker. Other members of the committee in 1920 were Edward B. Hatch, secretary of the Western Union and Rudolph Belcher, secretary of the Western Insurance Bureau. Every member of this original group has passed on, and their places taken by others who have carried

Continued on page 36

Grease

New Industrial Applications

By

John R. LeVally

The science of industrial lubrication, from the standpoint of the lubricants themselves, has received the attention of the best engineers and chemists in the petroleum industry for years, but the application of these lubricants, particularly the solid and semi-solid greases, and the equipment to apply them to the bearings, has been largely developed within the last 15 years.

The problem of "greasing" automotive vehicles is primarily responsible for most of the basic developments and improvements in equipment for the transfer of greases from refinery containers directly to bearings under pressure, and modified types of this equipment, originally designed for the "grease rack" of a service station or car dealer, built for heavy duty and large capacities, are now making the lubrication of industrial machinery easier, cleaner, and more positive, with a marked saving in maintenance, outage, and cost of lubrication.

The development of lubrication equipment in the automotive field took place more rapidly than in the industrial field very probably due to the direct profit motive involved. The "greasing" of a car or truck is not only a direct source of income to the owner of a service station or car dealer, but the lubrication department is also a main "feeder" source for other income producing services. This direct income, profit motive put the necessary push behind the development and improvement of equipment to do the job faster, cleaner, and more efficiently.

Lubrication in the industrial field has always been considered an item of overhead or expense instead of a direct profit item, and for this reason the men responsible for improvements in methods and equipment have not always been able to gain the ear of management for necessary appropriations, and modernization has often lagged.

The first development in grease lubrication under pressure was of course the invention of the pressure fitting for the bearing, and the matching coupler, which permitted grease to be pumped into a bearing under pressure from a hand pump. In the automotive field, the familiar "pin type" fitting was first introduced during and immediately after World War I, with lever-operated and push type hand pumps or guns and pin type couplers used to pump the grease into the bearings, through the fittings. About this same time, mine cars were first lubricated by a similar method through a "flush type" fitting.

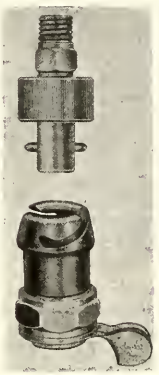


Fig. 1



Fig. 2

This method of applying grease to a bearing under pressure, by hand pumping through a fitting, rapidly gained favor in the automotive field, replacing the old grease cup on all automotive vehicles, and pressure lubrication fittings soon became standard equipment on all automobiles and trucks.



Fig. 3

While this idea did not take hold so quickly in the industrial field, peculiarly the first power-operated grease pump was developed for the lubrication of mine cars, and at about the same time a high pressure, wire-wound, rubber hose was developed to carry the grease from the pump to the bearing under pressure.

This pump was a single acting piston type, operated by compressed air, and developed 20 times the air pressure, or approximately 2000 psi grease pressure with the usual 100 psi air pressure available.

Again the automotive industry, recognizing the value of this power-operated system of lubrication,

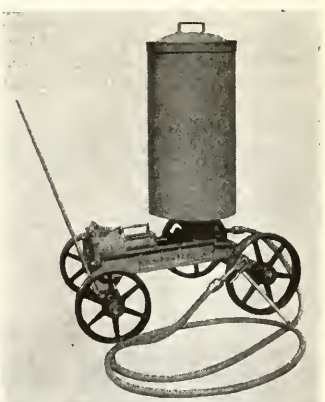


Fig. 4

adopted the power pump or compressor almost immediately, and while industry continued to apply grease lubrication by hand or by grease cups to a large extent, power lubrication under high pressure became the standard



Fig. 5

practice for all automotive vehicles.

For a number of years these air-operated grease pumps were made with capacities of 1 lb., 25 lbs., and 75 lbs., but all had a container that had to be filled, which meant transferring the grease from original containers to the pump container. This necessitated handling the grease, which is always a messy job, and also made it impossbile to prevent some degree of contamination with dirt, dust, etc. In 1931, after years of experiment, a two stage grease pump was developed that would pump the grease directly from the original grease container received from the refinery, through a hose, valve, coupler and fitting into the bearing. This was probably the most important development made in this field after the original power pump, as it enabled the operator to put grease directly into the bearings from the original refinery containers without any handling or exposure to contamination.



Fig. 7

Improvement came rapidly after the development of this first "barrel pump", and designs were perfected by refinements in pumping mechanisms, foot valves, etc., so that today pumps are available that will not only pump all kinds of greases, from the lightest to the heaviest viscous and fibrous types, from original drums and deliver under high pressure through pipe lines, hoses, etc., but will also pump such other materials as mastics, putties, deadening compounds, sealing compounds, rubber cement, etc., from original containers.

At the same time that these high pressure pumps were being developed, similar types of barrel pumps were developed to handle oils, gear lubricants, and liquid products at medium or low pressures, for use on assembly lines, etc., where large volumes were required in fixed quantities.

Along with the advent of the barrel pump, improvements were made in the types of fittings and couplers used to apply the grease to the bearing, such as the button head, dot, zerk and hydraulic types. Automotive vehicles followed a standardization program and with each improvement the whole industry adopted it, thus preventing confusion. This was not done in industry, with the result that even today there is no set standard as to type of lubrication fittings a machine may come equipped with, and a plant often finds its equipment fitted with several different types of lubrication fittings.

1942 found the Ordnance Department of the U. S. Army receiving equipment made by practically every manufacturer in the country, and since there was no standardization of the type of lubrication fittings used, single pieces of equipment would have three different types of fittings on it, where sub-assemblies were supplied by different contractors. This caused such confusion in the field, necessitating each vehicle having a multiplicity of nozzles and attachments for their grease guns to fit all three types of fittings, that Ordnance called on the manufacturers to design a fitting



Fig. 6

for universal use that would pass the volume of grease of the button head type, and could be contacted with the hydraulic type nozzle, which was more generally used. This resulted in the development of the "Bullneck" hy-

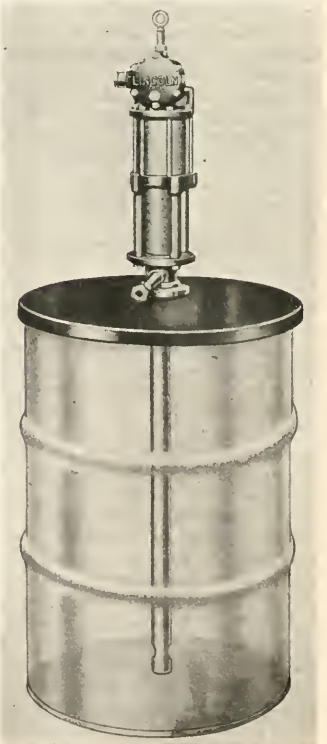


Fig. 8

draulic type fitting, known as Ordnance Standard, "CLDX6A", which is now standard for all types of equipment built for the Army.

This standardization might well be followed by industrial designers and engineers in the use of lubrication fittings, as the present practice seems to be to use whatever type of fitting they happen to think of, or used on the first machine they built.

The one purely industrial development in equipment for lubrication with grease is the so-called "Centralized" system, in which the grease pump feeds grease to the bearings under pressure through measuring valves, or injectors. With these injectors, a predetermined, measured amount of lubricant can be pumped into the bearing, and with proper automatic controls, this measured amount can be fed at regular, timed intervals. Two types of centralized systems are in use for this purpose; one using a dual feed line from the pump to the bearing through the injector, in which the effect is obtained by reversing the direction of flow in the feed line, and the other using only one feed line from pump to injector, in which the effect is obtained by releasing the feed line pressure between cycles. Both of these systems can use the barrel type pump to advantage, pumping the grease from original containers into the system, either air or electrically operated.

Oil companies have made the finest greases available for every purpose and condition, but all too often they find the machine or plant they are servicing inadequately equipped to handle the grease they recommend, and put it in the bearings when, where, and how it should be. This forces them to furnish a grease, not from the sole standpoint of what is best for the bearing condition, but limited by the ability of the equipment, or lack of equipment, to handle the proper grease.

Good grease, properly applied, is still cheaper than new bearings, plus lost output, and in the high production period of World War II this fact has been brought home forcibly to industrial management, with the result that more thought and action has been put behind providing adequate equipment for properly applying greases.

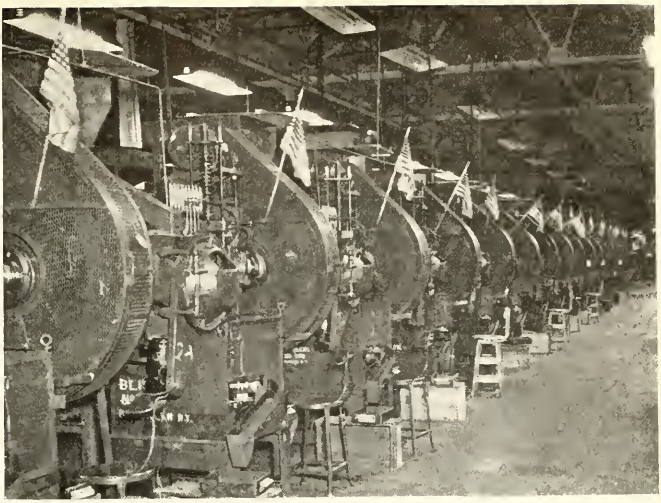


Fig. 11

Small Business
Can It Have Research?

By

Dr. Francis W. Godwin

The following article first appeared in "Pulling Together," a publication of the National Small Business Men's Association. It is reproduced here with the permission of the author.

That small business needs research and technology just as much as big business does, is too well recognized to admit argument. We could just as well debate the value of insurance, and the parallel would be pretty exact, at that.

But every so often somebody comes up with the assertion that the big, powerful industrial corporations have a monopoly on the scientific brainpower, and that we should do something drastic to save the small manufacturer who is "being driven to the wall through technological starvation". According to this story, the big corporations have hired all the research men, are reaping all the new scientific advances, and of course control all the patents; small business hasn't a chance, unless there is a revolution, or the government controls all the scientists, or we redistribute the patents, or something. What are the facts?

Admittedly, a lot of research men are employed by large concerns. Can we blame these concerns for hiring them, if they have found that it pays dividends? These are the men who create the new products, the improved processes, the savings in production costs, the competitive advantages. That we all know. The research men simply go where they are wanted.

Not only do the large concerns have technical men on their regular payrolls. They also utilize outside consultants, industrial research organizations, and engineering firms. They place fellowships in colleges and universities. Very sensibly, they make use of all the research and technology that are offered. What is more, a surprising percentage of these companies—including names that come to mind at once when anyone speaks of "big business"—started doing this when they were small manufacturers themselves. Could this not have had something to do with their growth?

A frequent charge is that the

Continued on page 43

The Endless Frontier

Commencement Address of October 20, 1945

By

Dr. John Day Larkin

My first impression of the term "commencement" was that it was a misnomer. Just why the exercises of a graduating class should be called a commencement seemed puzzling. To me, to commence was to begin, not conclude something. After several years of witnessing college commencements the connotation now seems more fitting. The young man who looks upon graduation from college as the end of his education, rather than its beginning, is not likely to distinguish himself as an educated man or as a leader in his chosen field. At graduation time, he has little more than a foundation upon which to build. His distinction will be marked by the structure which he erects upon this foundation. And that will depend upon his plans and the passion with which he pursues the task of future building. Thus we may say that he is beginning. We may rightly say that his graduation time is the point of his commencement. In short, now that you graduating seniors have finished with a curriculum, you may begin your education in a broader sense.

Man is occupied and preoccupied with education for a reason which is simple, bald and devoid of glamour; in order to live with assurance, freedom and efficiency, it is necessary to know an enormous number of things, and the youth has both a limited capacity and a limited amount of time for learning. That is the reason. A young man who would be educated has to acquaint himself with that framework of knowledge which is common to us. But he cannot stop at that. He has to find something new. He has to make a place for himself which has not been preempted by his predecessors. In so doing he seeks and finds a new frontier. With one generation after another, this process is endless.

The fields of science and technology have been most vigorously exploited now for more than a century. The past five years alone have resulted in such breath-taking accomplishments in these



Dr. Larkin

fields that the world is aghast. We stand in awe of our own vast mechanism. The forces we have developed have overwhelmed our political adversaries throughout the world. Our technological force today is global. Our economic and financial force is global. Our political power and prestige is equally world-wide. In consequence we find ourselves as arbiters in practically all international conflicts. But our social thinking is provincial. And we have grossly neglected the humanistic studies. As one European philosopher has phrased it, "Civilization had to await the beginning of the twentieth century, to see the astounding spectacle of how brutal, how stupid, and yet how aggressive is the man learned in one thing and fundamentally ignorant of all else."

As a consequence of our great scientific and technological triumph, we have a world to remake. The younger generation cannot escape it. The problem is "here and now." Like life itself it has been fired at us pointblank and there is no possibility of postponement. The mere fact that we possess such power for human annihilation imposes upon those of us who have that power the superhuman task of using such force with a God-like discretion if we are not ourselves to become monstrous tyrants.

We face the problem of the establishment of an international order in which national communities will be effectively united. We have reasons to be pessimistic about our success in this direction. The most serious impediment is an atmosphere of emotional prejudice, the product of excessive nationalism abetted by the narrower interests of various economic groups, which beclouds the problems of international organization and prevents the application to them of scientific statesmanship. Nations are slow to realize the necessities imposed upon them by the growth of a world civilization. But the expansion of western civilization seems an irresistible process, an inevitable consequence of physical science. Social science, which, unlike physical science, must be the possession of the many if its fruits are to be attained, lags behind.

In spite of this irresistible technological process which has been spreading western civilization throughout the world, let us not assume that civilization is measured purely in terms of gadgets. This is true only in a limited sense. The wonders of the technical age help to facilitate communication, which is one of the most effective ways of overriding the barriers of ignorance and prejudice. But we have seen how the same technical devices can be used to opposite ends—to disseminate and to propagate narrowness and prejudice. Civilization makes the world as one not so much through such devices as through a gradual understanding of the complexities of human beings—and these are infinite in number and variety.

One of the great tragedies of this century is the conflict of technology and political provincialism, and by political provincialism I mean the pressures extended in government in behalf of and by special interest groups. Technology has made for *easier*

Continued on page 40

Gas AND THE
Business Men of Tomorrow



THERE is hardly an industrial or commercial establishment that does not use heat in some form—whether it be a bakery or a restaurant, a foundry or glass plant. When the energetic, forward-looking men who have planted our banners on the ruined pillboxes of the enemy return to take their places in our industrial and commercial life, they will find that one factor in modern production comes readily within reach of those with modest capital—that is Gas equipment for the application of heat.

True, there are giant Gas furnaces that represent substantial investment, engineered to do big jobs in a big way. But there are types of Gas equipment to fit every need—from the biggest to the smallest. That is one of the many advantages of Gas and Gas equipment—flexibility. Here is a fuel and a method of application that meets every need for industrial and commercial heat. It meets them economically, too, affording unit and overall savings that any business man or industrialist appreciates.

The Industrial Engineers and Commercial Representatives of local Gas Companies will be glad to discuss with these new industrialists and business men the advantages of modern Gas equipment and advise them in the choice of specific equipment.

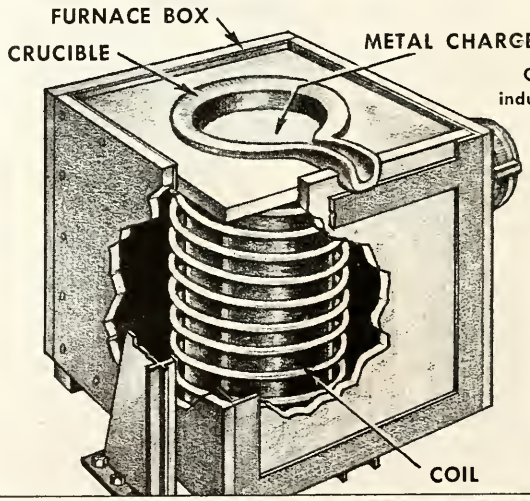
American Gas Association
Industrial and Commercial Gas Section
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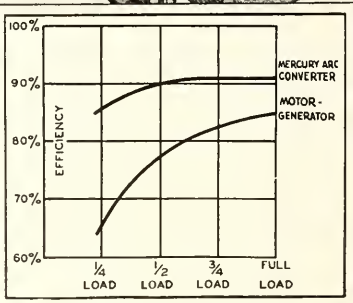
NEW FACTS ABOUT A-C'S WORK WITH INDUCTION HEATING— ANOTHER TEST OF OUR ABILITY TO SOLVE PROBLEMS IN ANY FIELD!

Inside view of Induction Furnace showing important application of Industry's newest electronic tool— Allis-Chalmers Mercury Arc Converter which supplies essential high-frequency current to induction heating coil.

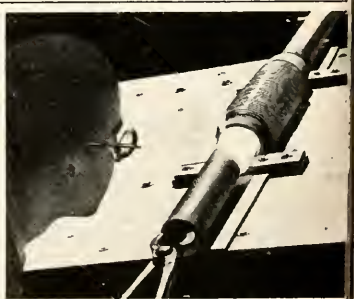




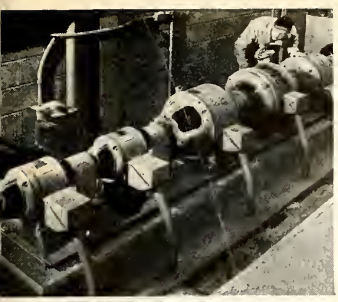
1 Today—already applied to induction furnaces, producing the energy that makes metals melt in their own heat with great savings of time and power — is an amazing electronic device made by A-C!



2 First applied to induction heating by Allis-Chalmers, the Mercury Arc Converter has proved superior in many ways to conventional rotating equipment—for instance *steps up efficiency 6 to 12%* (see graph).



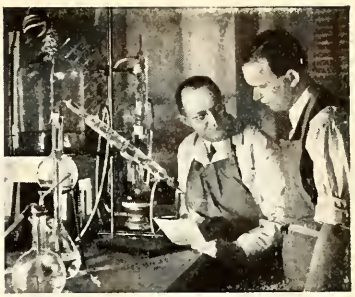
3 Other advantages of the Converter and induction heating: clean, flexible, easy to operate and control. Engineers predict for the future many new industrial possibilities in widely divergent fields!



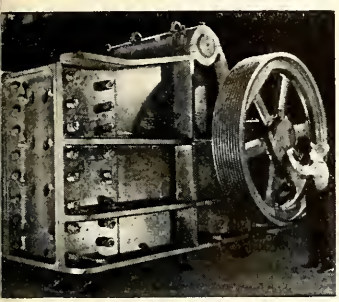
4 In other industrial fields, A-C engineering has been equally alert. To balance and control power accurately for special steel mill operations, we developed the "Regulex" Exciter Set, above.



5 The "Regulex" Control helps speed output of steel wire for bridge cables . . . regulates electrode position in electric furnaces—means extra "heats," more special alloy steel for peacetime use!



6 Wherever chemicals are processed for drugs, plastics, synthetic rubber, you're apt to find other important A-C developments at work—special pumps, sifters, scrubbers and rotary kilns.



7 The same is true of the mining and cement making fields. We outfit entire processing plants — make the world's most complete line of crushers, grinders, screens and other basic industry equipment.



8 Our new techniques, learned in war, will work for better peacetime living! Postwar homes, cars, food, clothing—*all* will be made faster, cheaper *and better* thanks to A-C "know-how" in many fields.



9 What's your technical problem? Our staff of experts can assist your engineers . . . offer careful, skilled analysis—new machines and methods to help speed output, meet keen competition. Call us.

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Man of the Month

David Siegel

The short life story that follows is about an alumnus who is a recognized leader in industry and at the same time has a deep interest in engineering education as a trustee of the Illinois Institute of Technology.

David T. Siegel is the founder and president of Ohmite Manufacturing Company, a firm engaged in the manufacture of rheostats, resistors, tap switches and other electrical controls. Interest is often expressed in the origin of the name Ohmite. The nature of the company's main products (rheostats and resistors) gives a clue. These being resistance units, and their application being determined by Ohm's Law, the name Ohmite was coined from the name of George Simon Ohm, the discoverer of the electrical law bearing his name.

Mr. Siegel was born on the West Side of Chicago, attended public school, and from 1909 to 1911 studied in the Lewis Institute Academy. While David was at Lewis, Professor Hawley of the Mechanical Drafting Department recognized his young student's ability and suggested that he put his training into action. At the age of 15 Siegel started to work for the Thomas Elevator Company as a draftsman, and several improvements in this company's products resulted from his inventive ability. Deciding in 1914 that he wanted additional schooling, he again entered Lewis and graduated in 1915. During this time he continued his job as a draftsman.

With the rumblings of war in his ears, Siegel enlisted in the Naval Reserve in 1917. He served on a mine carrier engaged in the hazardous work of carrying mines to Scotland for the North Sea mine field. Promotion rewarded his efforts and in 1919 he was released with the rank of Lieutenant (j.g.).

Forsaking the sea, David became the Eastern representative for the Foster Machine Company, Elkhart, Indiana, a manufacturer



Mr. Siegel

of machine tools. He conducted a sales office in New York City from 1919 to 1922, and one of the principal products in his line was an automatic chuck on which he had done some of the design work. In 1922 he returned to Chicago and to Lewis Institute where he completed his college work, receiving his degree in Arts and Sciences in 1925.

Apparently the urge to "go down to the sea in ships" got the better of Dave, because in the summer of 1925 he made a training cruise with the Pacific Fleet of the Navy to the Hawaiian Islands aboard a destroyer. After this voyage, he engaged in temporary work designing machines for making synthetic cotton out of wood pulp.

In 1926, the seed of his present business was planted. Mr. Siegel became interested in the radio industry, which was then just emerging from the home experimenter period into the mass production era. He started making grid leaks on a small scale. During this period he taught drafting at Lewis Institute. From his contacts with the radio industry, Siegel saw the need for a supplier of vitreous enameled resistors in the Western part of the country, the only manufacturer then being located in the East. He experimented and made many samples, in fact some of the dies for making resistor terminals were made in the shops at Lewis. In 1927, the resistor business required more space, and a small building at 214 W. Ontario Street was obtained. With eight employees, most of whom are still with the firm, Mr. Siegel manufactured grid leaks and vitreous enameled wire-wound resistors. On May 7, 1928 they moved to 636 N. Albany Ave.

The year 1929 saw the start of a world-wide depression, but it also marked the growth of Ohmite to 25 employees. The next few years witnessed a steady growth and the introduction of a line of wire-wound vitreous enameled rheostats. These rheostats included an innovation for this field, namely the use of a metal-graphite contact. In 1935 the firm, now consisting of 75 employees, moved to the present location at 4835 West Flournoy Street, where the newly built plant has since quadrupled in size and now employs more than 800 people.

From the very beginning, Mr. Siegel designed all of the special winding machines used in the shop and has always been closely identified with sales and production phases of the business. A majority of the new products have been the results of his inventive ability.

In 1931, Siegel married the former Dorothy Haas of Winamac, Indiana, and now has two children. His stepson is serving in the U. S. Army Air Corps. Mr. Siegel belongs to several organizations, among them being the Institute of Radio Engineers and the Physics Club of Chicago. He has traveled in South America and Europe, combining business with pleasure. Recently he established the Ohmite Laboratory for Precision Measurements at Illinois Institute of Technology, the

Continued on page 36



Birthplace of 50,000 RADARS

Two years before Pearl Harbor the Government asked Bell Telephone Laboratories to help perfect radar as a military instrument. The Bell System, through the Western Electric Company, its manufacturing branch, became the nation's largest supplier of radar systems.

Bell scientists designed and developed many different types of radars—each for a specific job. One particular type was standard for B-29s in the Pacific for navigation, target location and high altitude bombing. Another directed all Navy guns over five inches.

This is not surprising, for radar development and production stem from the same roots that produced and continue to nourish this country's telephone system.

BELL TELEPHONE SYSTEM

Man of the Month

Continued from page 34

purpose being, eventually, to have available to industry a laboratory approaching the work of the National Bureau of Standards.

When Mr. Siegel can take time off, his greatest relaxation comes from seeking and enjoying the quiet lakes and peaceful streams where fishermen delight to linger.

Fire Protection

Continued from page 26

on this great plan of helping in the development of fire protection engineering education.

The scholarship plan was unique in the magnitude of its conception and in the relations which it has fostered between the business of fire insurance and a technological institution such as our school. There is probably no other industry or profession in which the same degree of educational support has found expression or has been maintained continuously for a period of 25 years. Professor Finnegan, while not a member of the scholarship committee, was of invaluable assistance to the committee during both the preliminary organization of the plan as well as in the 25 years during which the plan has continued, giving of his wise counsel and judgment on many problems.

Beginning in 1920, the department expanded in numbers. The first class of scholarship students, made up of five men who were sophomores, graduated in 1923. There were 23 in the class of 1924, and from then on the department grew rapidly, at one time having well over a hundred men in the four year course of which some 99 were scholarship students. A very substantial number of men have enrolled in the department because it offered the best general engineering course available, combining as it does the essential features of mechanical, electrical, and chemical engineering in addition to professional courses in fire protection engineering. As of today approximately 550 men have been enrolled in the department, and about 80 to 85 per cent of this number are in some branch of the fire insurance business—companies, bureaus, agencies, brokerage concerns, Underwriters' Laboratories, and underwriting associations. It is still the only four year course of its kind in the country. Every man has been taught by Professor Joseph B. Finnegan. That is also a record which is hard to duplicate.

There are some interesting sidelights which should be mentioned in passing. At the height of the department's enrollment, J. V. Parker was a little perturbed when he discovered that about 15 per cent of the scholarship students who matriculated at the Institute did not graduate. He was told by Professor Finnegan that this was something to be proud of, for in other engineering courses and in other technical schools, it was seldom that more than 40 or 50 per cent of those who matriculated actually completed their work and graduated. Until World War II, and its serious effect on scholastic standards, the department of fire protection engineering consistently led other departments at the Institute in scholastic averages. There are also some interesting statistics available testifying to the merits of the department and our profession in the fact that beginning with Arnold and Emil Hepp, class of 1906 and 1914 respectively, about 40 pairs of brothers have taken the course and in two instances, three brothers have been in the department. Professor Finnegan's two sons are themselves graduates of the department.

When Professor Finnegan became head of the department in 1916, the work of instructing the Laboratory courses was taken over by Hamilton Alport of the Laboratories staff. Subsequently, O. L. Robinson of Underwriters' Laboratories became assistant and later associate professor in charge of this division of the department, and "Robby" has continued as Professor Finnegan's principal colleague ever since, being aided during the years from 1924 to about 1935 by Raymond O. Matson, S. J. McLaren, Carl K. Johnson, all graduates of the department, and Harold Norway of the staff of the Laboratories. The Western Actuarial Bureau also assisted since 1920 in making available instructors in schedule and field practice courses, and in this period Raymond T. Nel-

Continued on page 38

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Secretarial Training Service, Est. 1929, presents a highly personalized service for the development of proficiency in the Secretarial Arts in TWO months.

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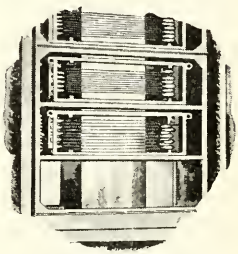
he started something that will never stop

25 YEARS AGO a Westinghouse research engineer started something that was destined to have a profound effect upon the lives of all of us . . . and upon generations yet unborn. That *something* was radio *broadcasting.*



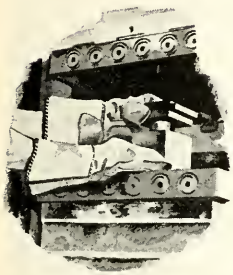
Radio broadcasting was born

on November 2, 1920, when the Presidential Election returns were broadcast from the tiny radio station, KDKA—built by Dr. Frank Conrad at the Westinghouse plant in East Pittsburgh, Pa. It was the first *scheduled radio broadcast* in history . . . the forerunner of a world-wide network that would eventually carry enlightenment and entertainment to the far corners of the earth.



Another "first"

by Westinghouse was the use of radio waves to fuse a mirror-like finish on dull electrolytic tin plate. High-frequency induction heating now helps make *one pound* of war-scarce tin do the work of *three.*



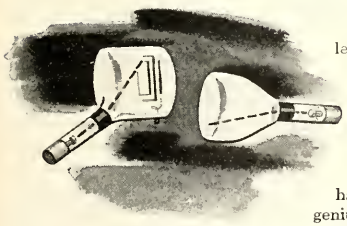
Dielectric death

. . . administered to weevils in grain elevators . . . is another example of the ingenuity of Westinghouse high-frequency engineers. Westinghouse dielectric heating equipment is today speeding the bonding of plywood and curing of plastics and synthetic rubber.



Frequency modulation

was pioneered by Westinghouse scientists as far back as 1920. At that early time they experimented with high frequencies that led the way to the static-free, crystal-clear FM we know today.



Television

has become a reality because of the genius of Westinghouse micro-wave experts, who developed the forerunner of the Iconoscope in 1923 and the Kinescope in 1929. These devices banished forever cumbersome scanning discs.



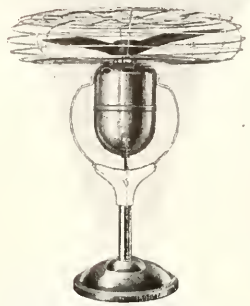
Research in microwaves

never stops at Westinghouse. Research, begun 20 years ago, resulted in the key electronic tube for the *first* long range Radar equipment. Other secret devices, born of war in the Westinghouse Research Laboratories, will contribute to a better, brighter peacetime world.

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PLANTS IN 25 CITIES OFFICES EVERYWHERE

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Reco RADI-AIRE CIRCULATORS



No. 1890. *Low Stand Model.* Finished with 20" and 24" propeller. Obtainable in enamel finish and chrome plating. Designed to blow up, but is adjustable to blow in various directions.

New Idea in Comfort Cooling



No. 1826. *High Stand Model Equipped with Coat Hanger.* Furnished with 20" and 24" dia. propellers. Designed to blow up but is adjustable to blow in various directions. Obtainable in enamel finish and chrome plating.

RECO Radi-Aire Circulators operate on a revolutionary new principle whereby greatly increased cooling comfort is obtained without the annoyance of sore throats, stiff necks, etc., as produced by the horizontal blowing or oscillating fan. Furthermore, there is no draft to blow papers and light material about.

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Fire Protection

Continued from page 36

son, Charles P. Holmes, K. H. Parker, Harvey O. Snediker, Jarl T. Sorenson, Swen H. Anderson, Fred F. Volberding, and John Hommes, the last seven graduates of the department, have assisted in teaching these courses. During the recent period when Professor Finnegan had to obey his doctor and give up his duties temporarily, John J. Ahern of the Safety and Security Branch of Army Ordnance (now director of the safety engineering department at I. I. T.), and F. W. Sandels, formerly superintendent of schedules of the Cook County Inspection Bureau, both graduates of the department, stepped into the breach and assisted in carrying on a number of Professor Finnegan's classes.

To get back to our main theme, we mentioned that Professor Finnegan had also become assistant engineer with Underwriters Laboratories in 1906. From 1910 to 1932 he was associate engineer in the protection department having primarily to do with fire testing, the design of equipment, and reports. In 1932 this connection ceased when he gave full time to the Institute and beginning at this time it seems as though he assumed sufficient responsibilities and duties to last several men.

From 1933 to 1936 he was director of research and testing at the Institute, doing the preliminary organizational and directional work that subsequently was lodged in the Armour Research Foundation when that was established as a separate research organization.

In 1936 he was chairman of the committee which revised the whole program of shop courses at the Institute. This meant a survey of all shop courses in the technical schools of the country. Radical changes were made as a result of this study.

In 1936 he was in charge of the organization of the co-operative course in mechanical engineering.

In 1938 he was chairman of a committee of the Institute which conducted a survey of in-service training in the Chicago area in behalf of the Chicago Association of Commerce.

In 1937 to 1942 he was in charge of high school publicity on behalf of the Institute.

In 1939 to 1944 he was editor of the Engineer and Alumnus, the Institute magazine.

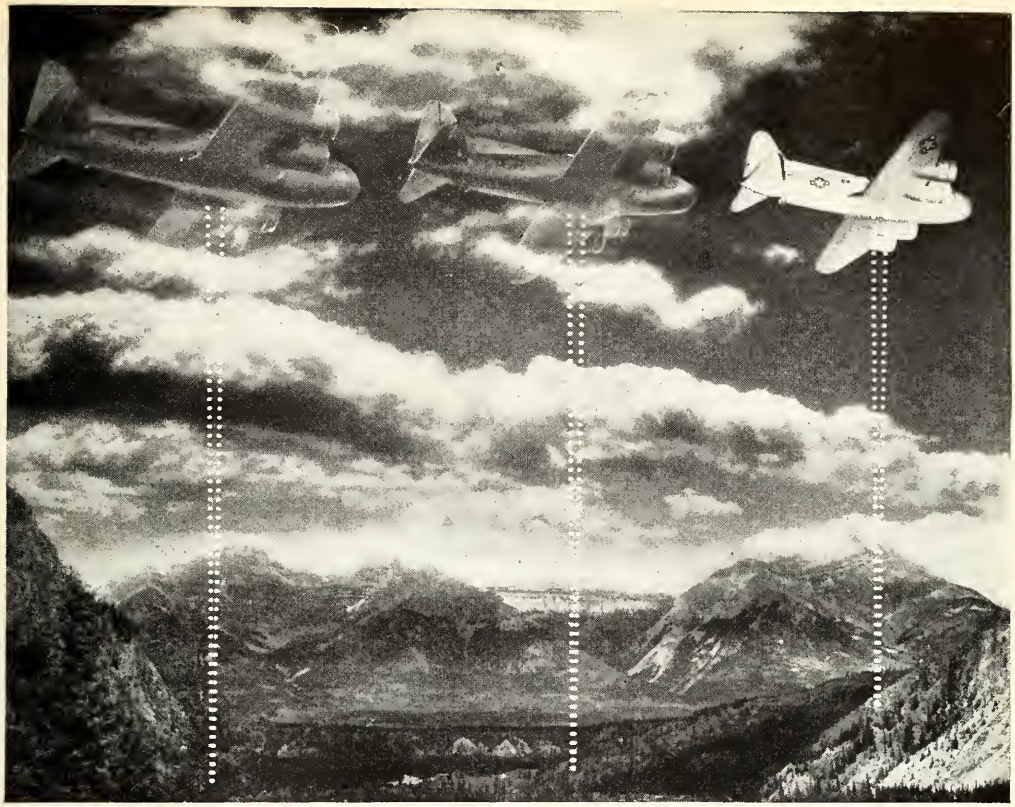
In 1942 he organized what was intended as the first of a series of conferences on aeronautics, but due to the war only one conference was held.

His war activities include the initial organization of the E. D. T. (Engineering Defense Training) program in the fall of 1940, the first classes being held in January, 1941. This program subsequently was expanded to require a full time staff and merged into the E. S. M. W. T. (Engineering, Science, Management War Training) program which trained some 52,000 men and women, one of the greatest training jobs done by any one school in the country.

Professor Finnegan also organized the fire protection engineering courses given by the safety and security branch of Army Ordnance to their safety men and gave many of the lectures himself. The E.S.M.W.T. gave some similar instruction to Army Air Force and Service Command men, and Professor Finnegan gave lectures in the fire protection courses to these groups.

With all these many interests, Professor Finnegan still has had time to handle a moderate amount of consulting practice in Fire Protection Engineering. He is a Fellow of the American Association for Advancement of Science, Member of the American Association of University Professors, Member of American Association of University Teachers of Insurance, American Polar Society, American Society of Mechanical Engineers, Associate Member of the National Fire Protection Association, serving as member of Committee on Fire Protection Engineering Education, and the Special Conference Committee on Fire Hazards in Hospital Operating Rooms. In 1937 he presented an address before the opening session of the National Fire Protection Association's Annual meeting in Chicago on the subject of "Fire Protection Engineering as a Profession." He is also member of the Western Society of Engineers and has served on their educational committee and for two years was chairman of their section on gas fuel and combustion engineering. He is a mem-

Continued on page 40



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Endless Frontier

Continued from page 30

and *larger* movements of goods, capital, persons and knowledge across political boundaries. Political nationalists have been busying themselves erecting walls that restrict all of these movements. This political reaction can be viewed in part as a defense against a too rapid pace of readjustment called for by a whole succession of startling technological changes. The result has been to put people to working at cross-purposes in a way that would be comic if it were not fraught with such serious consequences. One set of men builds tunnels through mountains, spans oceans with fast moving steamships and planes, develops better engines for transport, erects industrial enterprises designed to use the products of far places and to distribute goods in far places. Another set of men erects barriers to increase the cost of transporting goods from one place to another, devises new means of keeping capital within national boundaries, restricts the movements of persons and slows down the interchange of ideas. Thus a conflict rages between technology and politics. Economics, so closely linked to both, has become the battlefield. Stability and peace will reign in the world economy only when, somehow, the progressive forces on the side of technology and the reactionary forces of politics have finally been accommodated to each other.

There have been many European writers who have commented, with varying degrees of wit, upon this conflict which has gone on in Europe since feudal times. Friedrich List deplored the thirty-eight customs boundaries in Germany which crippled commerce as if each limb of a man's body were bound so that the blood could not flow over into another. To trade from Hamburg to Austria or from Berlin to Switzerland it was necessary to go through ten states, pay ten transit duties. More recently, Adolph Weber told of a man who went out for a walk. His hat was carried away by the wind, over the boundary, of course. By the time he had gone for a passport the hat was in a third state. And Ortega y Gasset referred to the European business man of twenty years ago as being in the position of a bird in a cage. When raising his wings to fly he could only beat them against the barriers. Few of us have realized how fortunate we have been in having the freedom of trade of forty-eight states. It is little wonder that we have large-scale, low-cost production, when each man in business has potentially 130,000,000 customers.

* * *

However slow the process, political groups do tend to accommodate themselves to the pressures brought on by technological progress. But I wonder how many of us realize by what painful processes it is done. Most of us think of violent revolutions as something fomented by a bunch of crackpots and wild-eyed radicals. It does not occur to us that behind this social turmoil the forces of technological progress are at work, breaking down old vested interests and the social strata which those interests maintained. There also has been a tendency to deplore the imperialism of the great powers; and yet the imperialist state is merely a form of political accommodation to the pressures brought on by technological change.

Another political adjustment to technological change that has made progress for a century and a half has been the rise of internationalism in many forms. In 1780 Jeremy Bentham introduced the word "international" into the English language and felt it necessary to apologize for using a strange word. There was not enough "internationalism" to make the word appear in print in the English dictionaries until 1877, although in legal circles there had been, for centuries, some formalized regulation of the dealings of sovereign states with each other. Beginning in 1873, and from that date to the present, there have been approximately thirty international organizations established and functioning. These cover a wide range of cooperative effort, from the setting up of an Institute of International Law, a Universal Postal Union, an International Bureau of Weights and Measures, and an International Time Bureau, to the establishment of a Permanent Court of Arbitration, a Permanent Court of International Justice, the now-lamented League of Nations, and

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Fire Protection

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ber of the Society for Promotion of Engineering Education, served on their Membership Committee, and as Member of the Council of the Society (1933 to 1936) organized the Illinois-Indiana Section and was its first president in 1935-1936. Last but not least, until last year he has been active in the fire prevention committee of the Chicago Association of Commerce, served as vice-chairman and was chairman last year until forced by reasons of health to give up this responsibility.

Professor Finnegan has six children, two sons and four daughters, and ten grandchildren. One daughter is married to Paul A. Hazard, Jr., and there has been much discussion in the family whether their children are "minor hazards" or "special hazards".

We have not tried to give in this outline all the many student activities and interests with which Professor Finnegan has been identified in his 40 years of service as instructor, professor, and finally head of the department. Time would not permit a recital of them and perhaps he rightfully feels that they are things that are expected of a man in his position. They involve what he has been to each one of us—teacher, advisor, critic, wise counselor, friend, and strong advocate of the best that each of us individually could put forward to advance ourselves and our profession.

Certain things stand out, however: his great devotion to the concept of fire protection engineering as being grounded on the basic engineering sciences as distinguished from the more popular or spectacular conception of "fire-fighting"; his support of high scholastic standards and encouragement of such standards through Salamander, the honorary student fire protection engineering fraternity; his interest in the formation of the fire protection engineering society as a medium for enlarging student contacts with professional men and organizations employing fire protection engineers; the unspoken pride he

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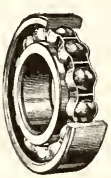


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Fire Protection

Continued from page 40

has had in the achievements of "his boys" and his modesty in never by word or deed assuming any of the credit for their development.

This is a brief history of 40 years of one man's associations and contributions to the growth and development of a profession whose purpose is to make not only the young student into an engineer, but one who understands his obligations to society and who will bear his share of the task of making fire the friend rather than the destroyer of our civilization.

The motto of the fire protection engineering society is the evidence of this purpose—"Speak true—Do right". There is no better tribute to Joseph Bernard Finnegan than to say that through his whole professional life and 40 years of service to the Institute, to the department of fire protection engineering, to the industry of fire insurance, and to us who are his former and present students, he has been a living example of that motto.

Gas Institute

Continued from page 23

taken when it is evident that the results will be of benefit to the Gas Industry.

The Educational Program of the Institute must be resumed as soon as possible, because a serious delay, common to all scientific education in the United States, has already resulted due to the removal by Selective Service of virtually all graduate students. The Institute expects the return of most of the former Fellows, and so a small but increasing group of highly trained and extremely able young men will be made available from year to year by the Institute. The cooperative phase of the graduate program will certainly be retained, so that the Fellows can have the benefit of actual experience in the industry.

Sponsored research projects, which have played such an important part in the growth of the Institute, will undoubtedly be continued, as the member companies learn that their problems can be solved through the application of systematic research by competent scientists. The report of the Research and Development division of the Institute is a very creditable record of work accomplished during a particularly difficult period. As manpower again becomes available, the permanent staff of the Institute will be selected from a much wider list of applicants than has been available during the past four years. By careful selection, a staff will be assembled which can make real contributions to the Gas Industry.

Director John I. Yellott has resigned to accept a position as Director of Research for the Locomotive Development Committee of Bituminous Coal Research. His group has already sponsored several projects involving applications of the Flash Pulverizer.

President H. T. Heald has announced the appointment of Commander E. S. Pettyjohn, U.S.N.R. as the new Director of I.G.T. Commander Pettyjohn, recently returned from active duty with a scientific expedition in Germany, will come to the Institute with a background of excellent work both in Gas Industry Research and in graduate education. Mr. Willien will serve as Acting Director until Commander Pettyjohn is able to take up his new duties.

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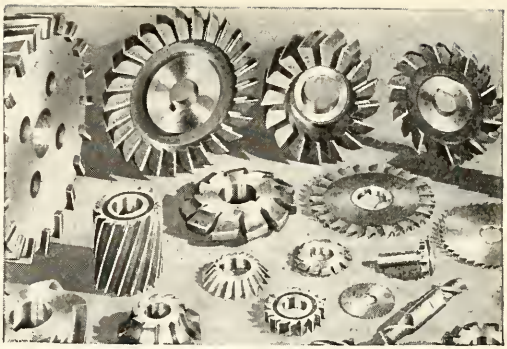
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Small Business

Continued from page 29

small manufacturer cannot afford technology. Let us examine this claim. A nationwide survey by the National Resources Planning Board showed, for companies using research, a median expenditure of 2 per cent of gross sales for this purpose; for the more progressive industries the rate was much higher. For your company, how much is 2 per cent of a year's gross sales? How can this amount—as a minimum—be invested advantageously in technology?

Among the minority of small manufacturers who do take measures to keep their output abreast of technical advances, some maintain small one-man or two-men experimental laboratories, supplemented by occasional specialized advice from outside consulting chemists, physicists, or engineers. Some retain such consultants on a continuing part-time basis. Some have a technical director but no laboratory, and take their research and development problems to one of the large industrial research institutes where, at moderate cost, they can receive the confidential services of an organized scientific staff and laboratory facilities as great as those of the huge corporations. A few industries have formed associations in which each business unit contributes its small share to the joint support of a substantial laboratory to solve the common problems of the industry; and in the best of these, provision is made to accommodate a confidential, privately financed research project for a member company.

By these and similar means, small enterprises are able to obtain technical aid in proportion to their willingness to invest in it. Costs may range from a few hundred or a thousand dollars per year for association support or consulting fees, to as much as a company wishes to put into it in all forms. Perhaps the one uniform requirement is that, in order to benefit fully from any technological investment, each concern must have in its own organization at least one technical man who can understand and apply the results. In a small organization this need not mean an extra man on the payroll, for the wise selection of a manager or production chief can often do the trick.

Then why not be realistic about it ? The plain truth is that most of our small manufacturers have not taken advantage of the technical help that has been readily available to them. Some have not included in their personnel a single technically trained man who could put into practice a few of the valuable things to be found in the local public library. The doors of consulting firms, commercial laboratories, industrial research institutes and universities have been open to them for years, but too many small manufacturers pass them by.

We grant that now there is a serious shortage of scientists and engineers, and we acknowledge that most laboratories are up to their ears in work. But it is not because of the small manufacturer. He hasn't placed his order.

Endless Frontier

Continued from page 40

the United Nations Charter. I point to these as moves in the direction of accommodating ourselves to the wider horizon which technological progress has opened up to us.

In the social and political fields there have been signs of the impact of industrialized western civilization throughout the world. A century ago the Orient was thought to be impermeable to such influences as those of the West. Yet Japan made tremendous strides in adopting and adapting the industrial techniques of the West; she copied the imperialistic ambitions of Great Britain; she devised a Monroe Doctrine of her own, called "the Orient for the Orientals"; and she added the militarism of Germany. China, which at first only suffered from the impact of external exploitation, in her very attempt to rescue herself, has opened her doors to the West. Turkey has discarded the insignia of her aloofness, the fez and the veil, and follows the economic and political pathways of the West. Russia, converted to an anti-capitalist faith, all the more eagerly develops a program of western industrialization. Industry and capital, whether under the banner of socialism or individualism are making of the world one civilization. The Industrial Revolution, which has been in progress for nearly two centuries is gradually preparing the world to become one community—one vast community but with myriad differences of smaller communities revealing more subtly and more richly the liberated expressions of the infinite variety of mankind.

Those of us who are here this evening—the people of this generation—have witnessed one of the major revolutions of history. We can recall when there were so many sovereign nations that we could scarcely enumerate them—each claiming equal status with all the others. Such sovereign authority was not seriously questioned until the rise of the Axis powers. Then one by one the small states fell prey to the economic pressure and the military threat of those powers which had the weapons of modern science and technology. Many of them went down without firing a shot. Others were overrun in a fortnight. Their so-called sovereign governments took refuge in foreign lands and appealed to other great powers to restore them. Some may be restored—after a fashion—but they are likely to enjoy about as much sovereignty as a medieval baron would enjoy in Moscow today. The big question of today is not whether there will be twenty-five or fifty states of equal power, independence and sovereignty, but whether there will be three or five. And what is more to the point, the question of tomorrow will be whether there is to be one power in world affairs or two. If it proves to be two instead of one, I do not see how we are to escape the consequences of a third world war within the lifetime of a large percentage of those present.

In fact, world wars are fought when there are but two major powers. Regardless of the number of satellites, there are essentially two powers in such global conflicts. World War I saw the Central Powers pitted against the Allies. Germany dominated the former, and in the end the United States was certainly the predominant power in the latter. In World War II—which has been a continuation of the same struggle after an armistice period of two decades—the situation has been quite comparable, with some modification in the alignments of the satellites. With all due respect to our allies, who suffered, by comparison, far greater hardships in both wars than we did, it is evident that we, instead of Great Britain, now hold the balance of power in Western Europe. Through the defeat of Japan, in which we contributed, by comparison, a greater amount of effort, it goes without saying that the United States, for the moment at least, holds the balance of power in the Orient. In view of this, who would question our being a most powerful force in world affairs, whether East or West? This position places us squarely in the path of Russia, regardless of which way she turns, for trade or for spheres of influence of any kind.

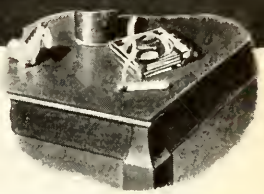
We use the term "spheres of influence" advisedly, for such spheres are the framework of the new imperialism—the twentieth century variety of imperialism as opposed to the colonial type of the sixteenth to the nineteenth centuries. Spain, the Netherlands, France and England were the great powers of those three centuries. And yet, where would the most powerful of them be today if it were not for Russia and the United States? No longer can it be truly said that England rules the waves. Nor can it be said that Mother England is the predominant political influence in many of those colonies which she once so proudly ruled. With this in mind, I hope we are not deluding ourselves about our own status in world affairs. We may well say that we have no desire to annex colonies. Annexing colonies is a thoroughly outmoded procedure in international affairs anyway. It is the better part of diplomacy today to live as good neighbors with those whose trade we seek, and over whom we hope to exercise a discreet measure of political influence. Economic penetration is a more subtle and generally more effective method of extending national influence in a world where popular support of government policies is essential.

Let us illustrate this point. After Mr. Hoover was elected to the presidency in 1928, he made a tour of South America to determine why our trade with Latin America had been declining in proportion to that enjoyed by European countries. He soon found out. Our Marines in Nicaragua had not only infuriated the population of that small Central American country but also that of all her neighbors south of the border. The appreciation of this caused a change in our Latin American policy. President Hoover saw that the marines were kept on duty elsewhere. Our Southern neighbors have since been treated with more finesse. And with the coming of the new administration Mr. Hull pursued this "good neighbor" policy even further through inter-American conferences and cooperative effort. This policy has paid dividends, as shown by the alacrity with which most of our Latin neighbors joined us against the Axis powers, instead of becoming centers for submarine bases, sabotage and bomber bases. And at San Francisco, it mattered not that Russia had four votes to our nominal one—or that Britain had six or seven. There were plenty of votes on our side.

Continued on page 46

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Endless Frontier

Continued from page 44

I repeat, we have a stake in the world at large. It is one to be cherished and preserved. It carries with it the gravest kind of responsibilities. By this I do not mean that we must go about with a grand military swagger, flexing our naval muscles offensively in the presence of our less affluent and less powerful neighbors, showing that we as a country are powerful. I mean simply that we have a choice of two alternatives: We may join with Russia, England, China and France—and all of the lesser countries—to set up some machinery for the peaceful and orderly solution of our complex global problems, or we may again prepare ourselves for a major war by the time the infants of today have reached their majority.

It is no secret that the youngsters of high school age, who missed the excitement of the war just concluded, are already asking when we are going to fight Russia. The grand strategists are also thinking and planning, if not talking, in a similar vein. In short, we have a major international problem since we do face Russia both in the West and in the East, with obvious rivalry, *not* over who is going to annex what territory, but over the spheres of influence, economic and political, which each is to exert in those allegedly free and democratic states which are to supersede the ones lately dominated by Nazi Germany. Either we try to work this problem out peaceably with Russia, or we prepare for war with Russia, with all of the holocaust that will ensue in an era of long-range, high-speed planes and radio-controlled atomic bombs. And there are no more hiding places in the world. There is no safety in distance. There is no security because of mountain walls or ocean expanse. Our only real security is in cooperation.

Of course we should like to think that with victory comes rest and peace and release from anxiety. It will annoy some of us to be reminded that victory has only brought us new burdens and new responsibilities. Yet it is so. The very instruments which won the victory for us have made it necessary that we find not only

Continued on page 50

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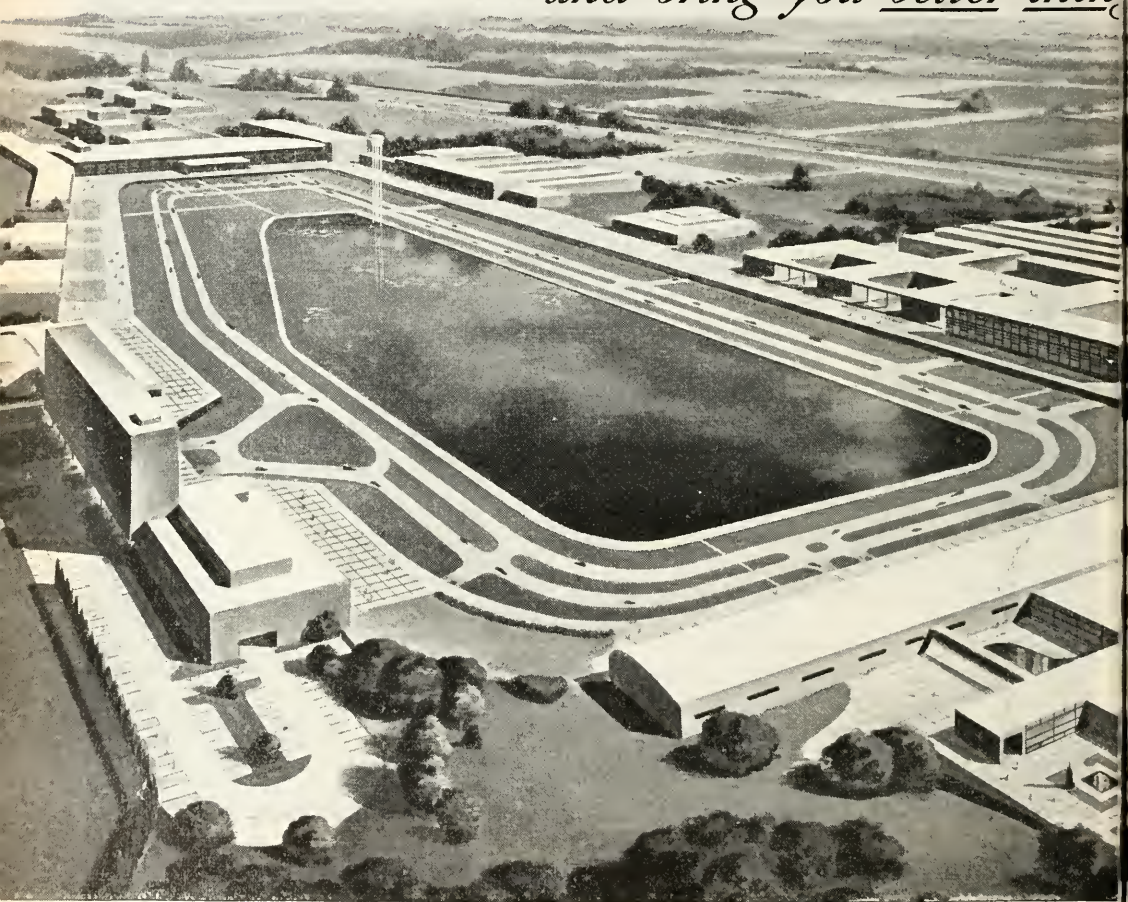
And these are but a few of hundreds of items that Corning is making for the military services in addition to glassware for industries that supply chemicals and clothing, food, powder, rubber, and gasoline! In these fields and in many others Corning's deep knowledge of glass and glassmaking has made it possible to put this fairly plentiful material to work, not merely as a substitute, but as a new material capable of standing on its own feet and delivering better service in many instances than the one it replaces. Keep this in mind when the peacetime developments you will be working on, reach the blueprint stage—glass is amazingly versatile in the hands of people who know glass. And Corning has spent nearly a century getting acquainted with it. So, when you get to those blueprints, write us. Corning Glass Works, Corning, New York.



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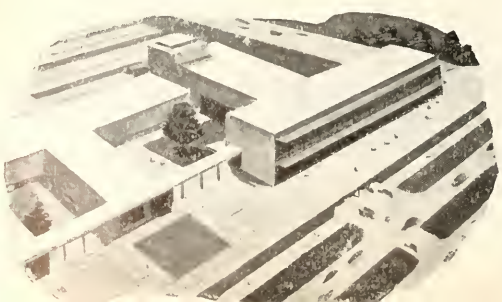
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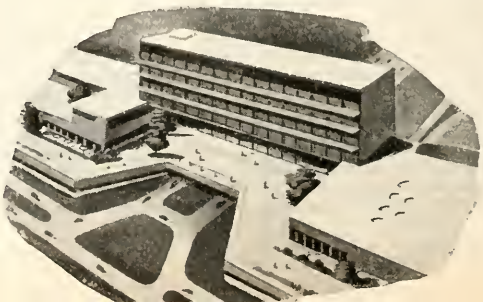
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THE BUILDINGS of the Technical Center will face a seven-acre lake. These buildings will be connected by a covered walk and vehicular roadway. Sketched below is the Advanced Engineering Building in which improvements will be quickly made in existing products.

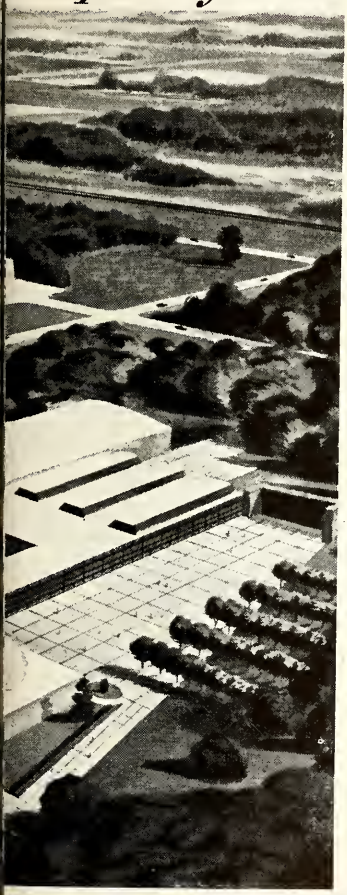
LOCATED ON a major highway leading from Detroit, access to the Center will be through the Administration Building sketched here. A system of modern roadways will provide practical opportunity to study traffic control as well as to make simple road tests of new car developments.



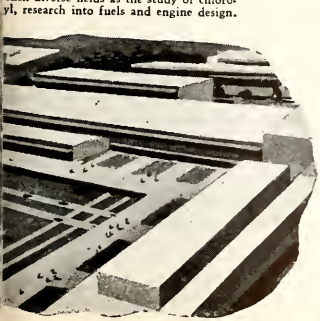


ROGRESS

ore quickly



FLOOD OF SUNSHINE will pour into the uthern windows of the Research Build- gs where experimental work is carried on such diverse fields as the study of chloro- yl, research into fuels and engine design.



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THESE are times when the world cries out for new and finer things. There is a great hunger, broad as all mankind, for happier relationships among men — for greater individual opportunity for accomplishment, for more and better goods within reach of everyone.

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The General Motors Technical Center is dedicated to such an objective. It will occupy a 350-acre tract of land outside of Detroit as soon as conditions permit. Its purpose is to develop new things that add to the comfort and security of our living, and to enable existing things to be made more efficiently, hence at lower selling prices, so more people may own and enjoy them — all with expanding job opportunities.

It will shorten the time required to bring the work of creative thinkers out of the idea stage and into usable reality.

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Science here will go to work in the interest of economic progress. And history is full of proof that when science is so harnessed, more jobs are created, more comforts and conveniences are brought within reach of more people.

Serving as a source on which the engineering staffs of all of our Divisions may draw, the General Motors Technical Center will stimulate improvement in all General Motors products. Automobiles, refrigerators, Diesel engines, locomotives and other good and useful things may be expected to be improved at even faster pace than in the past.

But the work of the Technical Center will not be confined to existing things. It is dedicated to the idea that progress is the servant of mankind and that whosoever advances it not only helps himself but his fellow men. Its goal will be "more and better things for more people," whether that comes through improvement of the old or development of the new.

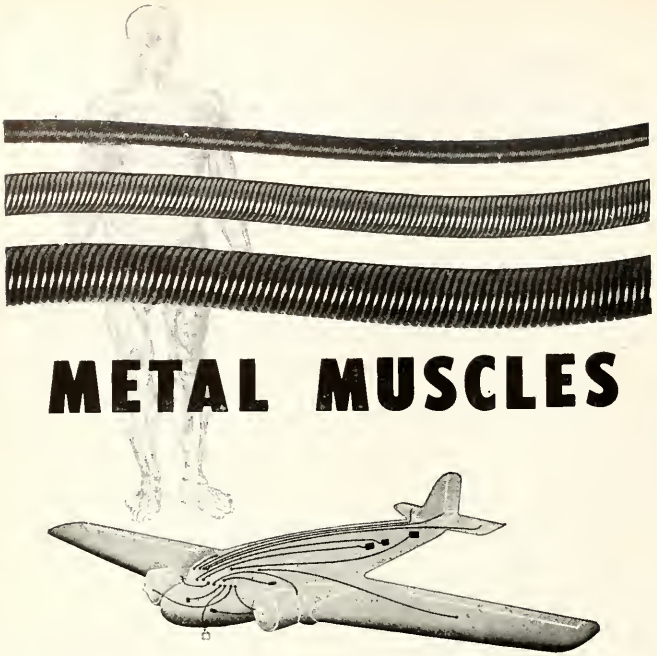
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Endless Frontier

Continued from page 46

means to control them, but also means to be secure in our homes and our lives until the control system has proved itself dependable.

In conclusion I should like to quote a few excerpts from the two final paragraphs of the text of the Army's official report on *Atomic Energy*, which was recently released.

"We find ourselves with an explosive which is far from completely perfected. Yet the future possibilities of such explosives are appalling, and their effects on future wars and international affairs are of fundamental importance. Here is a new tool for mankind, a tool of unimaginable destructive power. Its development raises many questions that must be answered in the near future.

"Because of the restrictions of military security there has been no chance for the Congress or the people to debate such questions. They have been seriously considered by all concerned and vigorously debated among the scientists, and the conclusions reached have been passed along to the highest authorities. *These questions are not technical questions; they are political and social questions, and the answers given to them may affect all mankind for generations.*"

* * *

You may ask why it is that the social scientists are always so far behind the progress of technology and the natural sciences. That is a fair question. The first and simplest answer is that the socio-economic problems generally arise out of the revolutionary conditions brought on by the progress of science and technology. As you can see, atomic power gives rise to a host of social and economic problems that could not possibly have been anticipated a year ago. Such is the case with every revolutionary scientific and technological step. *Second*, there is the inevitable social lag. It takes at least one generation for us to become accustomed to the newfangled ways. Our political adjustments must wait upon the reshaping of predominant vested interests and social prejudices. *Third*, we should note that attempts to approach social problems scientifically are yet in their

Continued on page 56

Iron Ore

What It Is, Where It Comes From, How Much Is Left

Prepared by

CHARLES A. SCARLOTT

The United States has sufficient unmined iron ore to last several hundred years. But, the present commercial sources are such that if we have to fight another war like this one we will be faced by an appalling shortage. We are not even now able to supply the needs of all the furnaces with ore that can be used without treatment to increase the iron content or otherwise improve its grade. These seemingly contradictory statements take a deal of explaining.

Scattered throughout nearly all states are many iron-bearing ores that, counting all grades, comprise a gigantic tonnage total. Just how large is the total, as with any underground resource, is not known with finality, although present estimates are probably reasonably close. Only minor discoveries of ore bodies have been made in the last two decades. The quoted figures of economically workable iron-ore reserves differ widely because many factors, some intangible, bear on their compilation.

Ironbearing formations of such low grade or location that they cannot today be considered workable ore may, through improvements in mining and steel-mill practices, be classed tomorrow as available. Then the estimates are subject to divergent opinion, some pessimistic, others optimistic The expression in print of these contrary views, often with some heat, has shocked the American public into the realization that what was once thought to be an unlimited source of rich, easy-to-get directly usable ore is not inexhaustible. According to some, it has a brief life of 10 years, or of 20 to 40 years according to others. Even the longer estimate of the life of the rich deposits is something of a shock.

What Constitutes Iron Ore

Making pig iron is a gigantic, multi-step refining operation. The start is made with iron-bearing formation, which may vary in iron content from 35 to 70 percent, and differ widely in amount and kind of impurities, in physical form, mineral and chemical composition. The ores as mined or concentrated are fed to blast furnaces that reduce the iron minerals to metallic iron and eliminate nearly all the remaining impurities. How much of the concentrating is done on the ore and how much is left for the smelting furnace to do is not rigidly fixed, but is a matter of design and relative economics. The blast furnaces between the Great Lakes and the Ohio River — where three-fourths of the steel in this country is produced—have been built to use ores from Minnesota, Michigan, and Wisconsin, referred to as lake ores. These ores, as sent to the furnaces, have for years consistently run about 51.5 percent natural iron or better. Some of them as mined can be used directly, but others are of poorer quality and must be mixed with ore of higher iron content or treated to raise the iron content. This process of improving the chemical composition or the physical structure of the ore is termed iron-ore benefication, a jaw-breaking term but meaning precisely what it says.

Whether a given deposit can be classed as iron ore depends not only on its iron content but on many other factors as well. Some of these are fixed by nature and others shift in response to changes in technology, and to economics, tax laws, and even to the policies of nations. Among the more important factors is the quality of the ore, that is, the proportion of the iron oxide, the kind of and amounts of accompanying impurities, and the hardness, porosity, and other physical properties. Others are cost of production and whether the ore can be mined from the surface or must be removed by more expensive underground methods. Geography, too, is important. Nearness of the ore body to sources of other essential raw materials—coal and limestone—and to the consuming markets for the product, pig iron, obviously is significant; and transportation facilities play a vital role.

Iron appears in ores predominantly as an oxide, of which one —rust—is familiar. Virtually all our iron is produced from three of the several oxide ores. These are hematite, magnetite, and limonite. Mother Nature was yavish as to the amounts she bequeathed to us but not too thoughtful as to where and with what she placed them.

Most iron occurs in ore as hematite (Fe_2O_3), which in pure form is 70 percent iron. Unfortunately it is non-magnetic and can't be concentrated by magnetic means. Ninety percent of total iron ore mined in the United States is hematite. Smaller quantities occur as magnetite (Fe_3O_4), which is being mined extensively. Magnetite contains 72.4 percent iron. Limonite ($2Fe_2O_3.3H_2O$), which can be considered as hematite combined with water, is a valuable iron ore and is mined in considerable volume. In pure form limonite contains 59.8 percent iron. Other oxides less completely hydrated than limonite also occur. Iron carbonate ($FeCO_3$), called siderite, can be used but it does not count for much among the totals of iron-ore reserves in this country or abroad. Also pyrite (iron sulphide, FeS_2) may be a source of by-product iron ore after roasting to recover the sulphur.

The iron-ore minerals occur in nature mixed in almost every conceivable proportion and degree of intimacy with other materials. The most abundant impurity, but not always the most objectionable, is silica, usually in the fine crystalline form, known as chert. In the modern blast furnace, silica acts as an acid, and must be fluxed with approximate-

Continued on page 56

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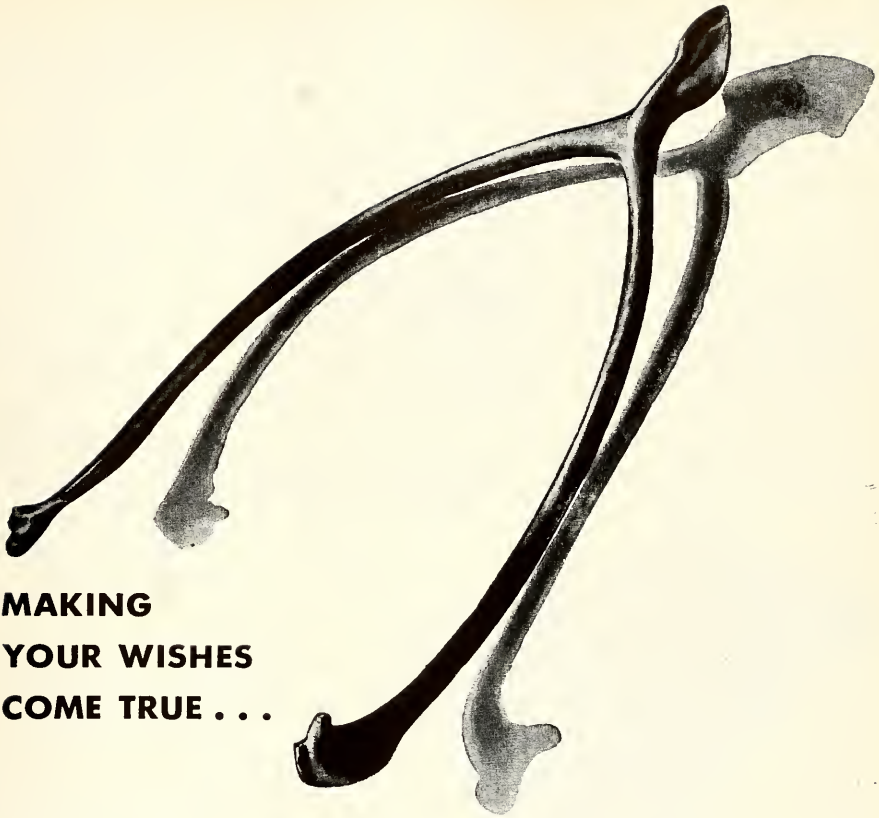


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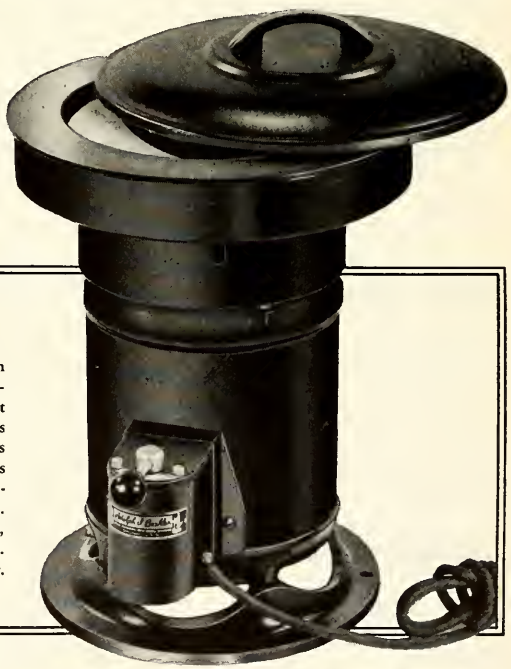
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Endless Frontier

Continued from page 50

infancy; whereas, what we now commonly refer to as the "scientific approach" began in the fields of the natural sciences nearly three centuries ago. For example, Aristotle's treatise on anatomy and physics, and his notion of "generation and decay" and of chemical processes, have long since gone by the board. But his politics and ethics are still revered. It has been only within the lifetime of some of those present that the study of social, economic and political problems have begun to escape the shackles of dogma, of undue reverence for ancient and medieval philosophers, of dealing with social problems in the abstract rather than as every-day problems. Too many social scientists have been solving problems that don't exist and ignoring a host of those that do. And *finally*, we must recognize that it is much more natural to be objective about non-social things. Even the greatest laboratory scientists cannot look with the same detachment and cold-blooded objectivity upon social phenomena as they do upon those phenomena which they observe through their microscopes. For these reasons those of us who are interested in the humanistic studies find ourselves inevitably lagging behind.

When you stop to consider all of the things to be done that now await you, I am sure you will agree with us that your preparation for the big job ahead is not concluded. You are but on the threshold. This is YOUR commencement!

Iron Ore

Continued from page 51

ly as much base (by weight) such as limestone or dolomite to produce the desired slag. Thus, in general, an ore low in silica is desirable. Conversely one of high lime content, making the ore all or partially self-fluxing, is highly desirable and may command a premium.

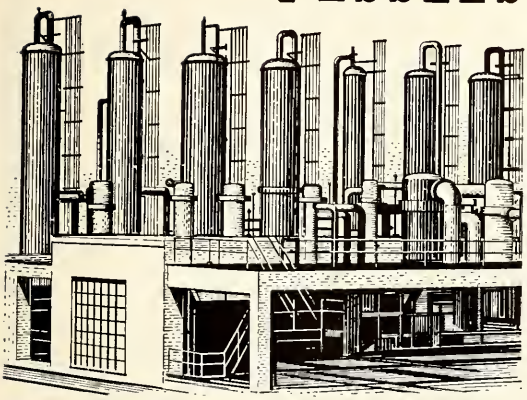
By a historical fluke the great Mesabi iron range belongs to the United States and not to Canada. The dividing line between Ontario and Minnesota was first set by the Treaty of Paris in 1783 but was so obscure and the maps so inaccurate it could not be located on the ground. John Jay, as Secretary of State, in 1794 proposed that the boundary line run from the mouth of the St. Louis river, at Duluth, to Red Lake, which would place both the Mesabi and Vermilion iron ranges in Canada. Fortunately the British rejected the proposal. After several abortive attempts to set the line it was finally fixed as it now stands by the Webster-Ashburton Treaty of 1842.

The benefit of this accident of blind bargaining to the industrial economy of the United States is incalculable. Mesabi ore is of good quality and easy to smelt; it lies close to the surface so that most of it is mineable in open pits. It is soft. It is enormous in volume. It carried the load of the emergency demand in the last war, and it is carrying the load in this war. However, the fabulous Mesabi pits cannot stand this accelerated rate of depletion forever.

Normal annual consumption of iron ore in the United States is about 50 million gross tons (1921-1940 average = 49.3 million tons). Of this, the Mesabi range alone contributed about 57 percent of the total. The demands of war have driven iron-ore production to an average peak of 100 million tons per year, of which the Mesabi produced 65 million tons. Its

Continued on page 57

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nearest competitors are the combined Michigan-Wisconsin area and the Birmingham districts, which produce only one fourth and one eighth as much, respectively. The Mesabi exceeds all other iron-producing districts combined, in tonnage produced to date, in tonnage of known reserves of both high and low grades, and in current rate of production.

The Mesabi range is one of those rare miracles of geology. It is flanked on the northwest by a low range of hills of granite and extends for about a 100-mile northeast and southwest direction, from a point 60 miles northwest of Duluth, at its nearest point. It takes its name from this range of hills —which the Chippewa Indians called Mesabi, meaning "giant." Thus the largest of all iron-producing ranges is appropriately named.

The "range" is a narrow band varying one to three miles in width. Actually it is the beveled, eroded edge of a thick iron-bearing rock formation—a series of sedimentary beds formed like many other sedimentary rocks on an ancient ocean floor. This old ocean bed has been tilted to the southeast at an angle of five to fifteen degrees.

The iron is thought to have been originally deposited mainly as carbonate. In the millenniums that followed, when erosion was active, the oxygen-bearing surface waters, percolating through the rocks, attacked the iron formation, breaking up the iron carbonate, producing iron oxide and carbonic acid. Water has solvent power for crystalline silica or quartz, which, although small, is promoted markedly by carbonic acid. In this slow but inexorable fashion, especially in the areas where earth movements had shattered the rocks more or less so that waters could move through them, much of silica was dissolved and carried away leaving the insoluble iron oxides behind. Nature, in short, did a part of the iron concentration job (beneficiation) for us. As a result of this leaching action, pockets of iron ore of various size and degree of concentration developed along the outcropping edge of the iron formation until the glaciers came along relatively recently and dumped their geologic debris over the surface, effectively halting the concentration process.

Some of these pockets of naturally concentrated iron ore are our great mines on the Mesabi range today. The ore, once the glacial overburden has been stripped off, is exposed as a soft, reddish to brownish rock, readily dug with power shovels after a minimum of blasting to loosen the ore banks.

The pits throughout the 100-mile range differ greatly in size. The natural-iron content of the ore as mined varies from about 40 to 60 percent. The pits vary from a few hundred yards to a mile or more in width and greater in length. The depths are as much as several hundred feet. The largest is the famous Hull-Rust-Mahoning pit at Hibbing, Minn., operated by the Oliver Iron Mining Company for the U. S. Steel Corporation and by Pickands, Mather & Company. In 1944 it produced about 21 million tons of ore. The total produced by that one pit since it was first operated in 1896 is approximately 375 million tons. It is three miles long, from one

half to one mile wide, and about 450 feet deep in places.

The average content of iron in the Mesabi ores as shipped runs pretty close to 52.0 percent (natural, or undried). The free moisture averages about 11 percent; the silica nearly 8; phosphorus, 0.062; manganese, 0.68. It does not contain serious amounts of titanium, sulphur or phosphorus. It is loaded by mechanical shovels onto trucks or dump cars, and moved out of the pits by trucks, locomotives, or by belt conveyors, depending on circumstances of the particular pit, to central points where it is loaded into 50- or 70-ton ore cars. Trains of these loaded cars are then hauled by steam locomotives to the ore docks on Lake Superior. About four fifths of this ore has come from open pits and the remainder from underground operations.

How much remains is uncertain and is a matter of controversy. The Minnesota tax commission in 1943 estimated that 647 million tons of open-pit ore and 413 million of underground ore of present commercial grades is still available in the Mesabi. Of this total of 1060 million gross tons, 902 million is indicated as direct-shipping ore and 158 million tons as concentrate that can be processed by present commercial methods. More than this may exist, but the possibility of there being a great deal more, particularly of open-pit ore, is generally conceded by experts not to be great. According to Minnesota laws, taxation on an ore body begins as soon as it is proved to have value. This obviously tends to discourage exploration. On the basis of the taxable reserves of 1060 million gross tons of ore that can be shipped direct or beneficiated by comparatively simple means, the ore of the Mesabi range is a little more than half gone—including the best and most easily mined portion—and it is far more than half gone in years of life because of the present high depletion rate.

If the war rate of production were continued, the known open-pit direct-shipping Mesabi ore would be gone in about ten years. But no one believes the recent depletion rate will continue. The average tonnage taken from the Mesabi over the ten-year period 1930-1939 was 21.6 million gross tons. The average over the twenty-year period, 1920-1939 was nearly 27.7 million tons. If mining continues uniformly on the Mesabi at the rate of 30 million tons, the life of the presently known reserve will be about thirty five years.

That end, however, will not necessarily usher in a day of iron-ore famine. Not even on the Mesabi. It does mean that the cream—the easy-to-get, low-cost ore—will be gone. However, other and still larger reserves of lower grade ore exist on the Mesabi. As has been shown, Mother Nature never completed her task of benefaction of the Mesabi iron-bearing rock, for only a small fraction of the total was leached of its silica and thus concentrated.

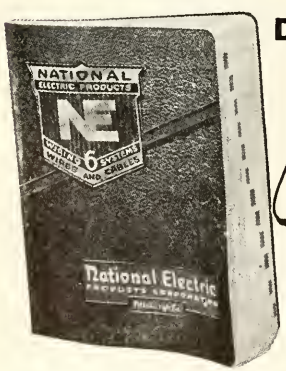
A rough classification divides Mesabi ore into three groups. The

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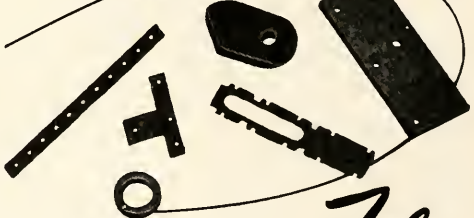


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Iron Ore

Continued from page 58

first comprises the ore bodies previously discussed. These total about a billion tons now classed as commercial and thus is taxable. Second is an intermediate grade ore, possibly a billion tons in total, in which the natural leaching process is only partly completed. This ore varies in iron content from about 35 to 50 percent. Almost all of it will require extensive beneficiation before it can be used in the present blast furnaces. It usually, but not always, occurs below the high-grade ore but sometimes around the borders or even above it, and much of it can still be mined by open-pit methods. It is a harder rock and requires blasting and subsequent crushing for the necessary concentration to increase the iron content.

Although this intermediate grade of ore clearly costs more to mine and to handle, the work of beneficiation has been partially done—sufficiently so that the process can be completed by known methods without excessive difficulty or expense. Economics, not technology, becomes the ruling factor. Where such intermediate-grade ore appeared on top of the high-grade ore being mined, it had to be removed anyway in order to reach the better ores. In some cases it was processed and shipped, and in other stockpiled.

The amount of ore from the Mesabi region subjected to all kinds of beneficiation before shipment is steadily mounting. It has increased from about 10,000 tons in 1907 to about 14 million tons in 1944, and undoubtedly this growth will continue. Concentrated ore now accounts for about 22 percent of the ore shipped from Minnesota and 18 percent of that from the outer Lake Superior district.

The third class of ore (really only potential or marginal ore) is the original, unweathered rock, locally called taconite. The volume of this is so large that one can think of it as practically inexhaustible. Less definitely charted than the other two grades of ore, it is estimated at many billions of tons.

Taconite is low-grade ore, varying in natural-iron content from about 25 to 35 percent, with 30 percent being an acceptable average. In some of the taconite areas the iron occurs as magnetite, although more extensively hematite predominates. Occasionally siderite occurs. The silica content is high, about 40 percent. This potential ore is in the form of hard rock in which the iron-oxide particles are small and intimately mixed with and attached to the particles of fineground silica, known as chert. These conditions necessitate drilling, blasting, crushing, and extensive subsequent treatment, all of which raise hob with costs.

The locations of the taconite and other marginal reserves are indicated approximately on the accompanying map. The location of these secondary reserves is significant. Because they coincide with the present high-grade ores and because of the locations of big beds of coking coal it would

Continued on page 62



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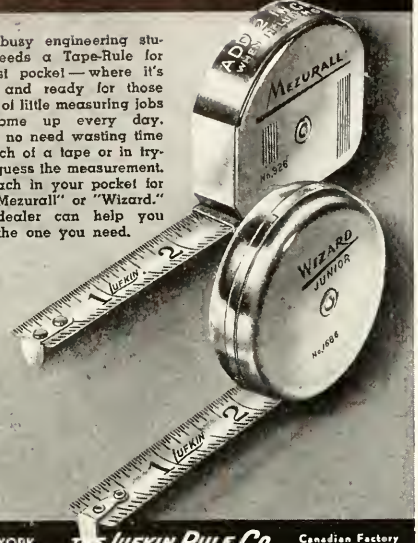
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Iron Ore

Continued from page 60

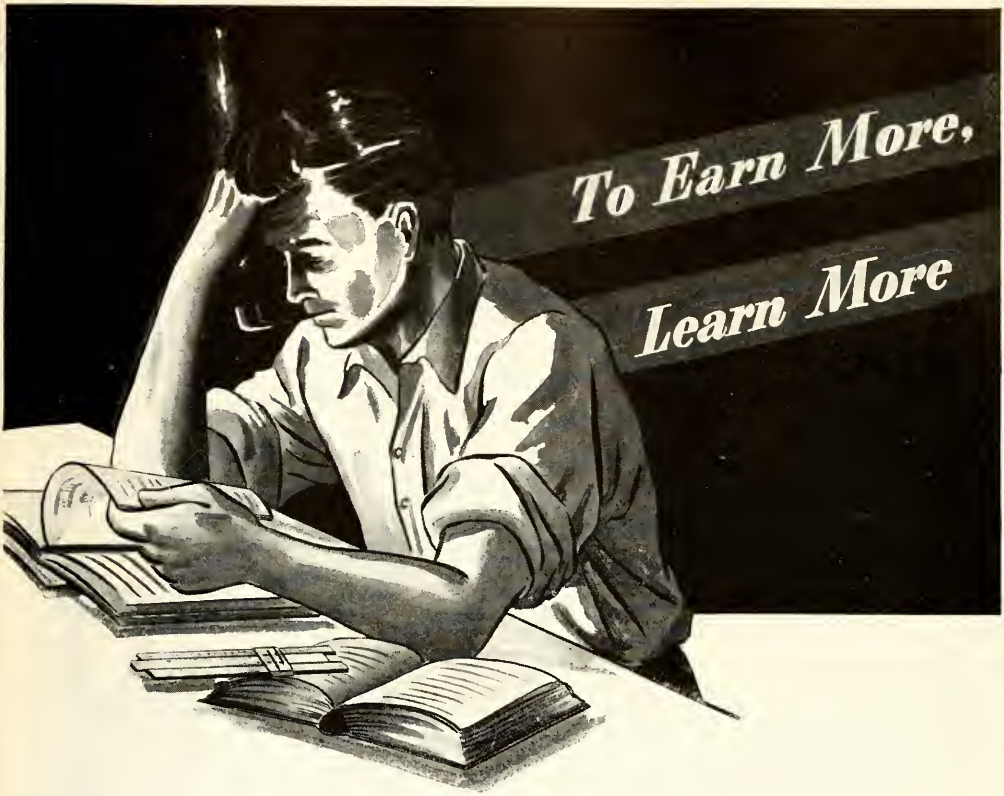
not seem likely that the physical locations of the steel-making industry are to be soon disturbed, even as the supply of high-grade iron ore runs low. Competition from imported ores would seem to have more effect on our future steel industry than any change in center of gravity of our own iron mining.

Although Mesabi ore by its immensity, quality, and accessibility overshadows all other iron-ore deposits in the United States, it is by no means the only one. The Lake Superior district, which comprises Minnesota, Wisconsin, and Michigan, has five currently worked major iron ranges in addition to the Mesabi. The Cuyuna, also in Minnesota, is thirty miles southwest of Mesabi, and is the only other range of this group in which the tonnage of ore from surface operations exceeds that from underground. The Cuyuna mines have produced about 53 million gross tons of ore that runs about 42 percent natural iron and ten percent silica. The ore is rather high in manganese, averaging 6.5 percent. About sixty five million tons of commercial-grade ore is the Tax Commission estimate of remaining reserves in the range. Production in recent years is about two million tons annually.

The Vermilion range, a few miles north of the Mesabi, and the Gogebic, Marquette, and Menominee ranges of upper Wisconsin and Michigan comprise the remaining four of the Lake Superior group. Although overshadowed by Mesabi, they are sizable and extremely important sources of highgrade iron ore. The three of the Michigan-Wisconsin group have produced to date about 650 million tons and currently are providing about one fifth of the Lake Superior total. The Vermilion and the three Michigan-Wisconsin iron ranges are primarily or entirely underground operations, although all of them have had and some still do have a few surface pits. Although mining underground is necessarily more expensive than from open pits, these mines can continue operation throughout the year, stockpiling their output during the winter motnhs when the Lakes are frozen.

The combined average annual output of all the Lake Superior mines, except those on the Mesabi, in the ten-year prewar period, is about ten million gross tons. In the ninety years since is opening, the Lake Superior district has shipped about 2100 million tons of iron ore. Ore still available in th eentire district, judged by present commercial standards of workable ore, is about one and one quarter billion tons, according to State Tax Commission estimates. About 175 million tons of this is from material that requires beneficiation before it can be utilized. How much ultimately will be added to this known reserve by future discoveries and economic and technologic changes is a matter of opinion. Some competent observers indicate expected additions of 25 percent to 50 percent or more, most or all of which will probably require beneficiation.

The above article reprinted from the Westinghouse Engineer will be concluded in the December issue.



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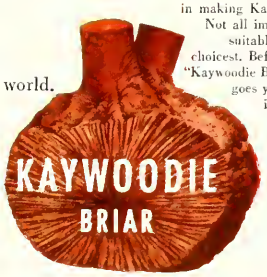
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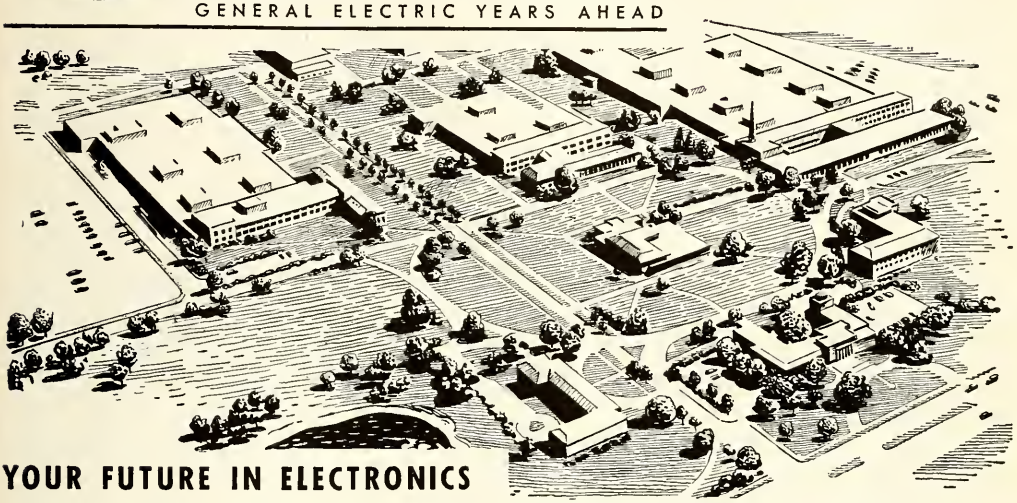
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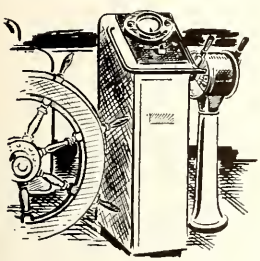
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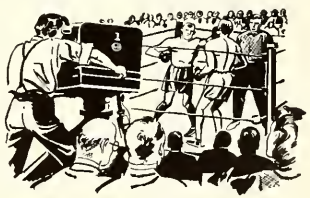


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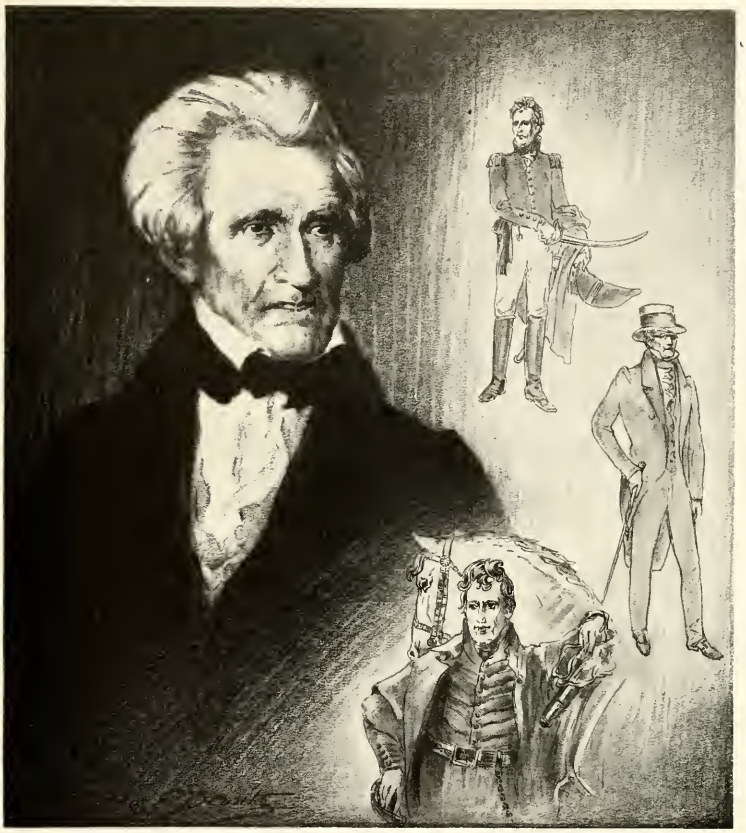
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ALUMNI SECTION

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Published in October, December, March, and May. Subscription rates, $1.50 per year. Editorial and Business Office, Illinois Institute of Technology, 3300 Federal Street, Chicago 16, Illinois.

ANDREW JACKSON — 1767 - 1845



In this brief discourse on Andrew Jackson, the man, his ideels and the work he did, it is not too much to say: "he was a man great enough, a man wise and good enough; wisdom to discern truly what the Time wanted, valor to lead it on the right road thither." These quotations are from Carlyle's "Hero-Worship",— and are most fitting, for is not Andrew Jackson,— "Old Hickory" one of our foremost national heroes?

His one act in itself would mark him such, when, in the dire crisis of the Union, he heroically faced the threatening spacter of secession by proclemation, stating in no mistaking determination: "that nullification violated the letter and spirit of the Constitution and was destructive of the great objects for which it was formed." "Our Federal Union! it must and shall be preserved!"

Andrew Jackson was born nine years before the Declaration of Independence, thus, in youth and growing manhood he was immersed with the spirit of the struggle for this new form of government.

The history of his subsequent records and amazing military career is too well known to need mention here. He became our seventh President, —the Jackson era is distinct in American history, "his strength at the cross roads of America was astounding." It was a very definite cross roads. He was the first President from west of the Allegheny Mountains and something of the wilderness of the frontier-spirit come into contact with the old order of the east, and the boundaries of our country were expanding from the Atlantic to the Pacific and from the Great Lakes to the Gulf of Mexico.

"Sam Houston, greatest of 'Old Hickory's' expeditionary captains, stood motionless before the candle-lit couch of death, then he dropped to his knees, and sobbing, buried his face on his chieftain's breast." He drew his little son, who was with him, to his side, saying: "My son, try to remember that you have looked on the face of Andrew Jackson."

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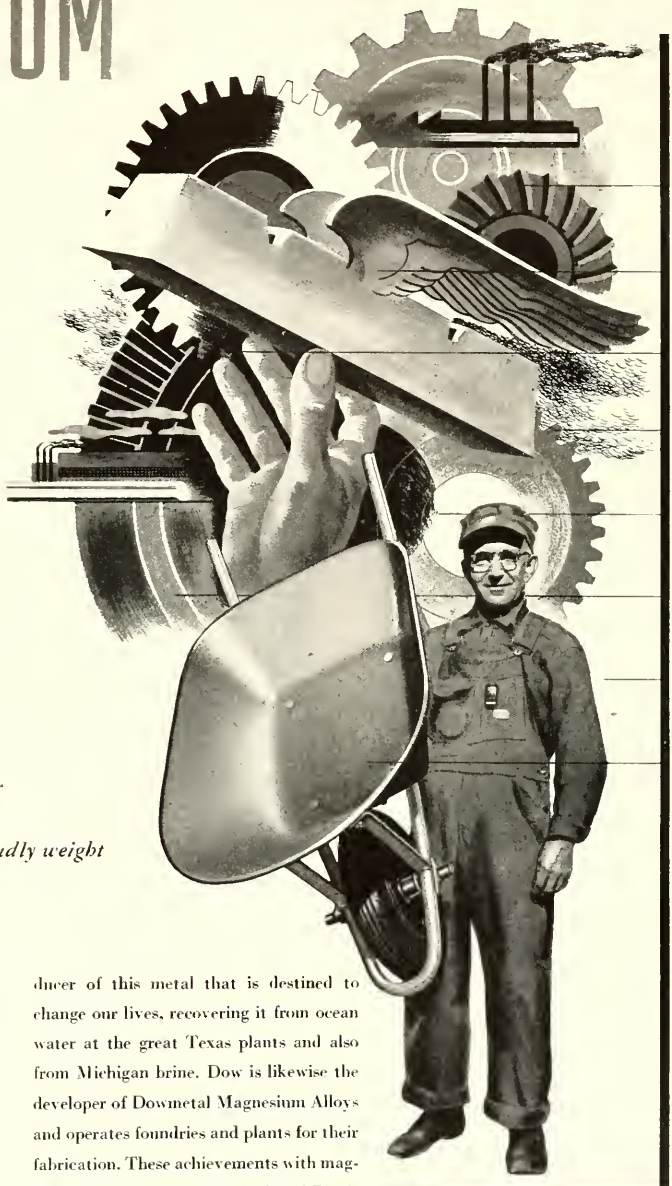
LINCOLN MAYTHAM is at present vice-president of the Wire Recorder Development Corporation. During the war he saw service as a lieutenant commander in the Navy and has recently been promoted to the rank of commander in the Naval reserve.

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Carbon Black

In War and Peace

By

LEONARD H. COHAN

"Of all critical and strategic materials, rubber is one which presents the greatest threat to the safety of our nation and the success of the allied cause." This statement of the Baruch-Compton-Conant Committee (29) was published on Sept. 10, 1942. Since that time the phenomenal efforts of the industries connected with the synthetic rubber program have made the rubber problem chiefly of historical interest. The happy ending, however, would not have been possible, despite the brilliant achievement of providing an adequate supply of raw rubber, had sufficient supplies of the other necessary compounding ingredients required for finished rubber articles not also been made available. Of these compounding ingredients carbon black is one of the most important.

Carbon Black Before the War

Carbon black is a soot-like material prepared principally either by the partial combustion or cracking of natural gas. Long before the present war this material had established itself as an indispensable ingredient for reinforcing and increasing the wear resistance of rubber articles. Reinforcement was of particular importance for natural rubber tires where as much as 25 to 30 per cent of the tire tread consisted of carbon black without which road life would have been reduced by more than half. In 1912 before the introduction of this reinforcing pigment, the life of a tire was only a small fraction of the 30,000 or more miles obtainable with first line tires in 1941. Although many technological advances contributed to this improvement, carbon black reinforcement was undoubtedly one of the prime factors.

The economic value of carbon black to American motorists was thus far in excess of its actual cost. Its real value was attested to by an ever increasing demand in response to which world production rose from less than 30 million lbs. per year in 1912 to approximately 650 million lbs. in 1941. More than 90 per cent of the total was manufactured in the United States chiefly from the residual gas obtained after the removal of gasoline from natural gas. For the most part the gas used was a waste product too high in hydrogen sulfide content and too far from large population centers to be used for utility purposes.

The Impact of the War on the Carbon Black Industry

In February, 1942, Singapore surrendered. The immediate effect of the Japanese offensive into the far eastern rubber growing areas was a drastic curtailment in the use of natural rubber in order to conserve our stock pile as much as possible. Non-essential rubber articles were eliminated, other production cut to a minimum, and wherever possible reclaim or other materials were substituted for natural rubber. Natural rubber consumption was reduced from nearly 800,000 long tons in 1941 to less than 400,000 in 1942 (68). As a result of this reduction and also owing to the fact that whole tire reclaim, the chief material pressed into the gap, already contained 15 to 20 per cent carbon black, demand fell off sharply during 1942. Stocks increased from 120 million lbs. in December 1941 to over 255 million lbs. in May, 1943 or well over six months supply at the then prevailing rate of consumption. Thus for the carbon black industry the chief immediate problem posed by the war was not one of production, but of warehousing.

Despite this anomalous situation both the War Production Board and the carbon black industry began to look ahead to the day when our expanding war industries would require much larger quantities of carbon black than ever before produced.

TABLE 1[a]

Type of Compound	Typical Carbon Black Loadings Required (% by Weight of Rubber Content)	
	GR-S	Natural Rubber
TIRES		
Treads (light tires)	45–55	45–50
Treads (heavy tires)	45–55	40–45
Carcass light tires)	35–50	Usually none
Carcass (heavy tires)	30–45	0–20
Tubes	30–50[b]	0–40
MECHANICAL *Goods*		
Belt covers	65–80	60
Belt frictions	25	None
Fire hose tube	55–90	None[c]
Gaskets	40–115[d]	0–150
Extruded goods	70–85	40
Molded goods	75	0–90
OTHER COMPOUNDS		
Wire insulation, code grade (WA)	40	None
Wire jackets	30–100	10–20
Shoe soles	135–165	10–100
Shoe uppers	85–100	10–70
Hard rubber (for some purposes)	40–100[e]	Usually none

[a] Figures on GR-S are taken from War Production Board reports, rubber data are from Vanderbilt Handbook *(91)* and other sources. Because of the wide variation possible in compounding procedure, the figures listed should only be regarded as illustrative of possible formulations.

[b] GR-I tubes also require about 30–50 parts carbon black.

[c] Barytes or other heat-resisting inorganic filler usually used.

[d] Loading increases with hardness desired.

[e] Where electrical resistivity is important only inorganic pigments are used. Hard GR-S does not require carbon black to develop satisfactory strength; however, carbon black is recommended in some applications.

Carbon Black Requirements of Synthetic Rubber

Experience with the synthetic rubber available before the war had indicated that the preparation of satisfactory tires of the butadiene-styrene type synthetic rubber (now called GR-S) required high carbon black loadings in tire carcasses and inner tubes as well as in tire treads. Likewise a host of other articles which require little or no carbon black when made from natural rubber seemed to need an appreciable amount when prepared from Buna S.

Immediately after Pearl Harbor the laboratories of all the major carbon black companies in cooperation with the rubber industry undertook an intensive study of the carbon black requirements of synthetic rubber. Much of this work has now been published (12, 20, 23, 24, 25, 35, 38, 39, 45, 54, 59, 74, 75, 80, 92) or distributed either as company

reports (1, 2, 3, 8, 10, 11, 13, 14, 15, 27, 28, 31, 32, 33, 34, 37.5, 41, 44, 47, 61, 64, 65, 79, 81, 82, 83, 84, 86, 87, 88, 91, 107, 110) or as reports issued by the War Production Board (43, 96, 97). These studies firmly established the vital role of carbon black in all synthetic rubbers and particularly in GR-S. Table I shows the per cent of carbon black required by various types of GR-S compounds compared to similar compounds of natural rubber. The increased use of carbon black in GR-S, particularly in large volume applications such as tire carcass and tube stocks is striking. Thus carbon black needs appeared likely to increase rapidly as our war production mounted, not only because the demands of our mechanized armies for tires and other rubber articles would exceed all peace time records, but also because each pound of GR-S demanded more carbon black than natural rubber.

New Plant Construction

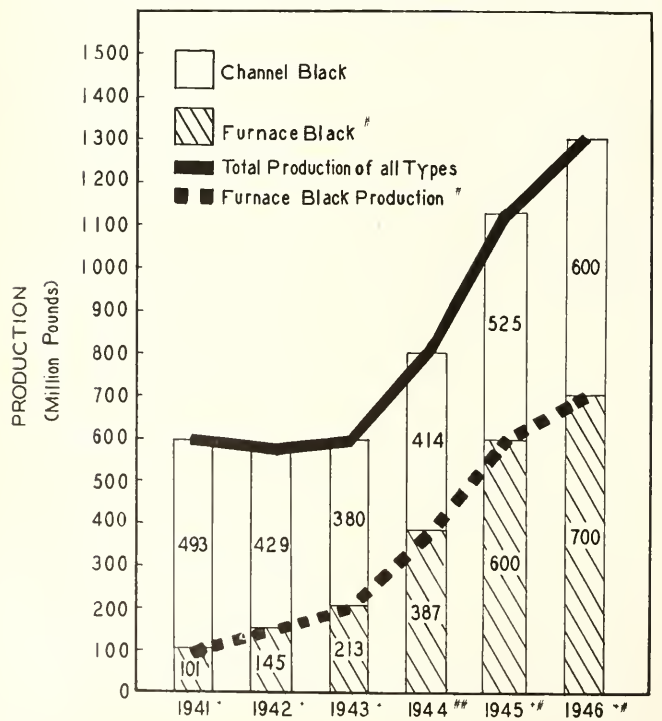
In October 1942 soon after the Baruch Committee report was published the writer estimated (93) that carbon black requirements for 1944 would amount to about 946 million pounds or about 250 million pounds more than scheduled production including new plants then planned. Similar estimates came from other carbon companies (102). Based on estimates such as these, plans for additional new plants were drawn up even while inventories were rapidly accumulating. Chiefly responsible for the vigorous prosecution of this planning was Thomas J. Starkie, head of the pigment and color division of the War Production Board. Also at the insistence of Mr. Starkie a carbon black technical advisory committee was brought together to help solve the problems confronting the industry.

Furnace plants were the first to be constructed because the blacks produced on these plants were more urgently needed than channel black in extending our precariously low supply of natural rubber. Furthermore, the steel and natural gas requirements of furnace plants are smaller per unit of carbon produced than for channel black installations (102). Figure I shows the actual and projected production of furnace and channel blacks from 1941 through 1946. During this period furnace black production will have increased almost seven times while actual increased production to date is more than five fold.

While furnace blacks are satisfactory for tire tubes, carcasses and other uses, they do not give as high resistance to abrasive wear as channel black, which is still the most widely used reinforcing agent for tire treads. The switch to easier processing channel blacks required by heavy military tires of natural rubber and by GR-S type synthetic rubber brought about a reduction in total channel black output during 1942 and 1943 since less of the easy processing type could be manufactured with the same plant installation. Throughout the latter part of 1943 the rapidly increasing output of synthetic rubber lead to demands for channel black which gradually reduced the large accumulated inventory. Early in 1944 it became obvious that if the most were to be made of our new rubber production capacity, more channel black as well as furnace black would be required (36). Most of the major carbon companies contracted to erect and operate channel plants for Defense Plant Corporation. The first of these new plants was put into operation by Continental Carbon Company on April 7, 1945; others, including Panhandle Carbon's plant at Eunice, New Mexico, began operating shortly after. Total U. S. production of all types of black will have increased from about 600 million lbs. per year in 1941 to a yearly rate of 1,125 million by the end of the current year.

FIG. 1. CARBON BLACK PRODUCTION, 1941 TO 1946

+ Burcau of Mines, Minerals Yearbook, 1943 (64).
Including thermal black.
Bureau of Mines, Minerals Market Report (63).
+# As estimated in Rubber Director's Report of 2-1-45 (16, 64).
The yearly production rate by the end of 1946 is estimated to be 1,450 million lb. (63).



Recent Shortage

The shortage of carbon blacks which occurred early this year was due to military rubber requirements considerably exceeding previous estimates and a remarkable expediting job on the part of the Army and the rubber

companies which enabled the latter to operate on a 7 day week, 24 hours a day. As a result consumption of carbon black ran ahead of production to an alarming extent. However, in the last few months many of the plants, under construction long before the shortage occurred, were expedited and have now come into production. Output has increased from 70 to nearly 100 million pounds per month (26) and is keeping pace with requirements. Emergency restrictions reducing permissible carbon black loading in rubber by 10 per cent were lifted in June.

Types of Carbon Black

The three principal types are channel, furnace, and thermal blacks. Channel blacks are prepared by the incomplete combustion of natural gas in small flames. These flames are formed by gas issuing from a small slot (about .040″ wide) in a ceramic tip of about 3/8 inch outside diameter. The air supply is controlled to give a smoky flame which impinges on the flat surface of a steel channel iron on which the carbon black is deposited. In Figure 2 a diagrammatic sketch of a channel plant is shown.

Furnace blacks are also produced by the incomplete combustion of natural gas.* The gas and air are introduced simultaneously into large furnaces where the reaction takes place. A flow sheet of the process is shown in Figure 3.

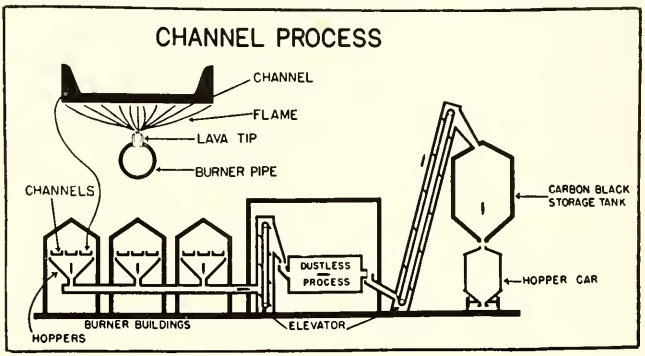
The third principal type, thermal blacks, are manufactured by thermal cracking of natural gas. The furnace is heated by combustion of an air-gas mixture; heating and gas cracking are carried out in alternate steps.** Figure 4 shows a diagram of this process.

Properties and Applications of the Various Grades

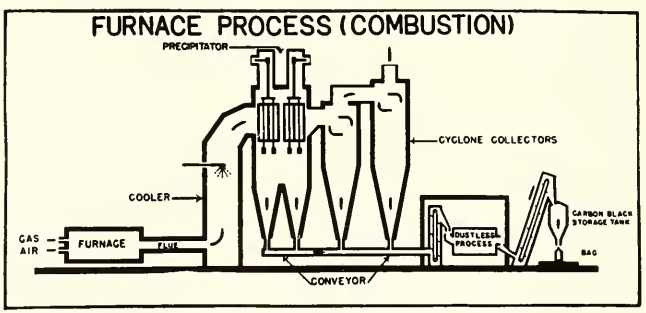
While all of the above types of black were manufactured before the war, the relative importance of furnace blacks has now greatly increased. Moreover the grades of black most widely used at present are somewhat different from the prewar standard grades.

In Table II the principal properties of the various types of carbon black now manufactured are shown. The table includes those blacks covered by the Standard War Production Board notation (94) and also acetylene and lampblack.

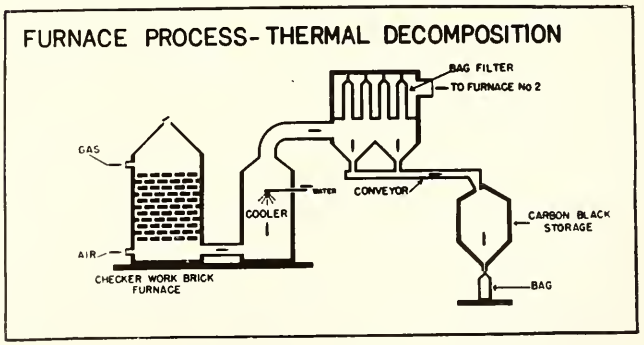
The easy processing channel (EPC) type is generally used for GR-S synthetic rubber while medium processing channel (MPC) and hard processing channel (HPC) were most widely used in natural rubber, particularly in the smaller size tires, before the war. The deficiency of GR-S in processing and resistance to heat development make these factors relatively more important than wear resistance, whereas with natural rubber the latter property was more critical. Thus EPC



Above. Fig. 3. Channel process for manufacturing carbon black



Above. Fig. 3. Furnace process for manufacturing carbon black



Above. Fig. 4. Thermal process for manufacturing carbon black

*In some cases mixtures of natural gas and oil are used, the products have properties between furnace blacks prepared only from gas and lampblacks which are prepared by the incomplete combustion of oil.

**Acetylene black is obtained by a special process consisting chiefly of the cracking of C_2H_2. Since C_2H_2 decomposes exothermally, no heating step is required.

Black which gives better processing and resistance to heat development than MPC or HPC is preferred for GR-S even though some sacrifice in wear resistance must be made. Recent compounding experience indicates that even in natural rubber the lower hysteresis obtained with EPC black can sometimes be used to good advantage from the standpoint of overall tire properties.

The previous standard furnace black, SRF, is still widely used in synthetic rubber. However, the somewhat finer particle size high modulus furnace (HMF) has also found favor. HMF provides better wear resistance than SRF and can, therefore, be used instead of channel blacks in heavy truck treads and similar applications. HMF is superior even to EPC in processing, resistance to heat development and flex cracking and, therefore, serves to complement GR-S which is weak in these properties. For many purposes blends of SRF or HMF with channel blacks or thermal blacks appear to give the best all around combination of properties.

Nature of Carbon Black and its Role in Rubber Reinforcement

The pursuit of the necessary practical information on the behaviour of carbon blacks in the new synthetic rubbers, to some extent overshadowed more basic studies of the fundamental character of carbon black. However, these studies, the continuance of which is so important in solving the practical problems of tomorrow, were not entirely neglected even during the war. In fact we now have a far clearer insight into the mechanism by which carbon black stiffens and toughens rubber compounds to such a remarkable degree and with such desirable practical consequences.

Particle Size and Structure

The electron microscope made possible for the first time, direct observation of carbon black and showed that practically all commercial blacks were composed of rounded particles of fineness exceeding that of any other commercial pigments (4, 9, 50, 73, 89, 90). Typical electron microscope

(Continued on page 36)

Table II

Type	WPB Symbol	Examples Conductex[b]	Average Particle Diameter *(104)* (mu)	Surface Area *(140)* (M.²/g.)	Surface Nature *(104)*	pH of a Sludge of Black in Water *(104)*	State of Aggregation in Rubber[a]
Channel, conducting	CC	Continental R-40[c] CX[d] Spheron N[e] Voltex[b]	10–20	250–125	Oxides of carbon, carbon and hydrogen	4–5	Normal
Channel, hard processing	HPC	Continental F[c] HX[d] Kosmobile S[b] Micronex Mark [b] Spheron No. 4[e]	20–25	125–100	Oxides of carbon, carbon and hydrogen	4–5	Normal
Channel, medium processing	MPC	Continental A[c] Kosmobile 66[f] Spheron No. 6[e] Standard Micronex[b] TX[d] Witco 1[c]	25–30	100–90	Oxides of carbon, carbon and hydrogen	4–5	Normal
Channel, easy processing	EPC	Continental AA[c] Kosmobile 77[f] Micronex W-6[b] Spheron No. 9[e] Witco 12[c] Wyex[d]	30–33	90–80	Oxides of carbon, carbon and hydrogen	4–5	Normal
Furnace, conducting	CF	Statex A[b] Sterling I[e]	36*(86)*	70*(86)*	Chiefly carbon and hydrogen	10*(86)*	Normal
Furnace, fine	FF	Statex B[b]	36*(86)*	70*(86)*	Chiefly carbon and hydrogen	10*(86)*	Normal
Furnace, high modulus	HMF	Continex HMF[c] Kosmos 40[f] Modulex[d] Philblack A[g] Statex 93[b] Sterling L[e]	50–60	60–50	Chiefly carbon and hydrogen	10*(86)*	High
Furnace, semireinforcing	SRF	Continex SRF[c] Furnex[b] Gastex[h] Kosmos 20[f] Sterling S and R[e]	70–90	42–30	Chiefly carbon and hydrogen	9–10	Normal
Thermal, fine	FT	P-33[i]	150–200	20–15	Chiefly carbon and hydrogen	7	Low
Thermal, medium	MT	Shell Carbon[j] Thermax[i]	250–500	10–5	Chiefly carbon and hydrogen	7	Low
Acetylene[l]		Shawinigan Black[k]	43*(28A)*	64*(28A)*	Chiefly carbon and hydrogen	5	Very high
Lampblack[l]		RMV[b] Witco lampblack[c]	100–200	12–24	Chiefly carbon and hydrogen		

[a] As judged by oil absorption, Sweitzer and Goodrich (*86*), and by electron microscope, Wiegand and Ladd (*102*).
[b] Columbian Carbon Co.—Binney and Smith Co.
[c] Continental Carbon Co.—Witco Chemical Co.
[d] Huber, J. M., Inc.
[e] Cabot, G. L., Inc..
[f] United Carbon Co.
[g] Phillips Petroleum Co.
[h] General Atlas Carbon Co.—Herron Bros. and Myer
[i] Thermatomic Carbon Co.—R. T. Vanderbilt Co.
[j] Shell Chemical Co.—R. W. Greef and Co., Inc.
[k] Shawinigan Chemicals, Ltd.
[l] Types not officially designated.

The Veteran
In Contemporary Education

By

John F. White

In any discussion of the problem of veterans education, one must first set the stage by pointing out that the veteran problem is NOT a problem in the sense the man on the street refers to it: one hears individual after individual, group after group worrying out loud about what problems will be created when our veterans return to civilian life. A person might almost think that we are about to dump 8,000,000 psychoneurotics into civilian life and that almost all of that group will invade our campusses. Such is, of course, NOT the case. Certainly veterans returning to college have a reorientation problem the answer to which is time and time alone; they also have their problems—academic, marital and financial BUT taken as a group they are no different than any other group of a similar size and age level.

The real educational problem hinges around that phrase—"age group". These men we meet as freshmen in our colleges and universities have come back from military service from 3 to 5 years older than the typical freshmen. Their study habits have thus suffered but at the same time we must remember that insofar as their maturity is concerned they are even older—they are many times young old men.

This maturity has its advantages and its DISadvantages. On the one hand they are serious about this job of education, know what they want and are determined to get it. On the other, this maturity places upon us—the educators—a real responsibility insofar as guidance is concerned. We must get square pegs into square holes; we must protect the man from aiming too high and I use the word protect advisedly for it is always easier to say "Son, go up higher" than it is to say "Son, you belong a notch or two lower on this educational ladder" and yet THAT is what we must do if we are to avoid complete confusion. Those



JOHN F. WHITE

of us who are interviewing these veterans have seen the typical airforce man who wants to be an Aeronautical Engineer, the Signal Corps man who wants Electrical Engineering or the Radar man who thinks he can walk in the front door and walk out no longer than two years later with an Engineering degree in his pocket. This inflated ambition is in the majority of cases caused by a lack of knowledge of what is involved in the work toward such degrees and the career later. In most cases it can be handled quite easily but it takes time and equipment—equipment in terms of adequate trained personnel. This we must by all means have if we are to meet our responsibility.

Again, this reference to walking out with a degree two years later brings into focus another problem. Until the veteran gets his feet firmly placed upon the ground, he wants to finish his education and start making money in the quickest possible time. In fact, too many want Engineering simply because they have been led to believe that this professional degree is a free pass to easy and big money. Money—easy and big—is foremost in the minds of a great many men who now face civilian life. Let me read to you a letter which was received by a friend of mine. This man had written to a number of his acquaintances who were Army and Navy Chaplains. He wrote to Chaplains realizing that they probably better than any other group in the Military would know what their men wanted when they got home and that was exactly the information he sought. Here is a typical reply:

"You ask what these brave men under my command are thinking about in terms of after the war. As near as I can make out, I think I do know what is within their minds, they long to get back home as quickly as possible, to the best land on earth, the U.S.A. Why does it seem to them the best land on earth? Because they think they can have good jobs there, with good pay and easy work to do, security from want, freedom to say any old thing they please, a good time for them and their girls, maybe some but not many children (though most of them do not seem to think that far ahead). I myself agree that all these are mighty good things for any man to have; but I am not at all sure that life ON THOSE TERMS ONLY is worth the living, or that a country whose way of life is determined by these desiderata is apt to remain either a good country or one likely to survive if brought into competition with such a country of mystics as, for example, Russia.

Such a life as my men long for and talk about leaves out too many things that matter. It leaves out the passion for mutual sacrifice which our fathers knew. Most of my men are so absorbed in the immediate that they have no long-term view of America or of man. Their way of life leaves out, too, that haunting wistfulness about life, that sense of tragedy to be surmounted at great cost, which is back of poetry and music, the sort of thing which makes men gentle and living an art. It leaves out,

in short, the things of the spirit. You and I were brought up to value that which lies deeper than the surface. We seem to have become un-American, precious, impractical, ridiculous in the eyes of a young America which has rarely been taught to esteem or to enjoy more than the sensory and the utilitarian and the obvious."

I am inclined to believe that this Chaplain has hit the nail on the head. These are the men we have to work with. The accent on money which permeates their thinking is not all whim: these men in college have added responsibilities which our typical students do not have. Large numbers are married, and many already have families or will have them soon. They are older and interested in getting jobs while jobs exist to provide for those families. What they DO NOT think of is providing for them while in college.

Under the G.I. bill the married man can receive only $75 a month for subsistence. While the man under Public Law 16 gets $103.50 per month with $5 additional for each dependent, he too must either work or have his wife work in order to live decently. If a family exists even that possibility is difficult. The **housing** of married veterans is a problem we must face and face now. Urban universities and colleges have many times had to tell the married applicant to find a house or apartment first and apply for admission later. Even if college facilities can exist for housing the married veteran we face a grave question of policy—for the question before us is whether the married college student has come to stay—if not can we afford to build or rebuild facilities for the present group?

Housing has been seriously complicated by the end of the war. In fact the end of the war has brought us face to face with many problems. In September at Illinois Tech our Admissions Office interviewed 551 veterans; in the month of October that figure was 704. This huge increase in personal inquiries came close to crippling our facilities. It did not break but it badly bent our whole office set up. If that is our situation, one must shudder at the load which is now being carried by the Veterans Administration. They are now interviewing over 500 men a day and each of those men means paper work. The Veterans Administration facilities like our own are badly bent and their faltering has made our position even more untenable. It now takes between a month and six weeks for a veteran in Chicago to receive his letter of eligibility after he has applied for it. Far worse is the subsistence situation for there we find that men are not receiving their first subsistence checks for at least three monts after they enter training. For the married veteran or even the single man this has meant an extremely precarious position. We all know of course that our institutions are having their difficulties in keeping tuition payments from the government up to date or even anywhere near up to date. One who works with the veteran and the veterans administration wakes up nights cutting red-tape —absence reports, grade reports, drop notices, issuing and collecting supplies and equipment—details which we NEVER faced before must be met. Last year when we had comparatively few veterans on our campusses was bad enough but NOW with at least double the number of men that load has become almost too heavy and a day of reckoning will be upon us all. Something MUST be done. Above all we must take a realistic attitude, cooperate and mediate—education and the Veterans Administration must be brought together, must work together, to solve what may become a delicate situation.

This is not, however, the answer to the whole problem, for the individual veteran is above all the most important factor. Educational institutions have a responsibility which must be met. We must provide for close counselling before and during his collegiate career; we must survey other educational possibilities at lower levels for NEVER should we send a veteran out of our offices with the simple statement—"no you cannot come to our college"—our answer ought to be in each case of rejection—"you do not qualify for training at this level but indications are that—" followed by frank, honest, and solid advice. It is not fair to simply say NO—we must either readvise or send the man to some agency where he can be revised.

IF we will do this, and IF we will offer refresher courses for those men we accept, and IF we will go along with them for a period of time until they can become reorientated in their study and class-room habits, we will have here as strong a group of students as we have on our campusses. At Illinois Institute of Technology we have seen this work—the grade average of our group of veterans during the last semester for which data is available was higher than that of any other group on campus At Illinois Tech we have a Veterans organization which has played a large part in the success of the veterans program. It is a strong, cooperative, constructive body of men, affiliated with no national organization, and yet no one of us can tell a veteran from any other student.

The returning veteran does not need coddling from the colleges and universities, soothing syrup, flattery; he needs to be told that he is the product of an infantile civilization, that like most Americans he is a child crying for candy, that if he has any real manhood in him he will regard America as something more than a glorified factory, movie house, ball park and corner drug-store. He needs an educational system which makes it clear that it cares about him and is grateful to him and admires his courage and efficiency but which insists, because it loves him well and truly, that the things that really matter are, many times, quite beyond his untrained cognizance. He needs colleges and universities which will tell him the truth about his own incompetence and the incompetence of the generation which bred and trained him. That is our responsibility and those are our problems—are we ready to meet them?

Any questions which alumni and former students have concerning educational benefits obtainable under the GI Bill of Rights can be answered by addressing the inquiries to John F. White, assistant dean of students, Illinois Institute of Technology, Technology Center, Chicago 16, Illinois. If sufficient interest is shown by readers in this type of article and specific questions are asked which could be answered in another of the same type, Mr. White will oblige in subsequent issues.

Fire Protection and Safety

Western Society of Engineers

Dr. Henry T. Heald, President of the Western Society of Engineers, recently announced the appointment of a committee of distinguished engineers and educator in the fire protection and safety engineering fields to formulate plans for the creation of an active group in the Chicago Area to present programs covering fire protection and safety problems that will be of interest to engineers not only in these respective fields but to all engineers and operating personnel.

It seems logical to form this group within the Western Society of Engineers since the Society has as its objective the advancement of the theory and practice of engineering without regard to any particular group of engineers. Further, it is evident that a definite need exists for closer coordination of fire protection and safety engineers with one another and also with the other engineering professions.

The committee to study this problem, as announced by Dr. Heald, is made up of the following engineers and educators:

John J. Ahern, (Committee Vice-Chairman) Professor of Safety Engineering and Director of Department of Safety Engineering, Illinois Institute of Technology.

Bolton G. Anderson, (Committee Secretary) Assistant Secretary, Western Society of Engineers.

J. Earl Harrington, Consulting Engineer.

W. J. Fairbairn, Engineer, Factory Insurance Assoc.

Joseph B. Finnegan, Professor of Fire Protection Engineering and Director of Department of Fire Protection Engineering, Illinois Institute of Technology.

John D. Gallagher, Safety Engineer, Hartford Accident and Indemnity Co.

A. H. Jens, (Committee Chairman) Chief Engineer, Springfield Fire and Marine Insurance Co.

Herbert W. Lange, Sales Manager, Fire Division, Cardox Corp.

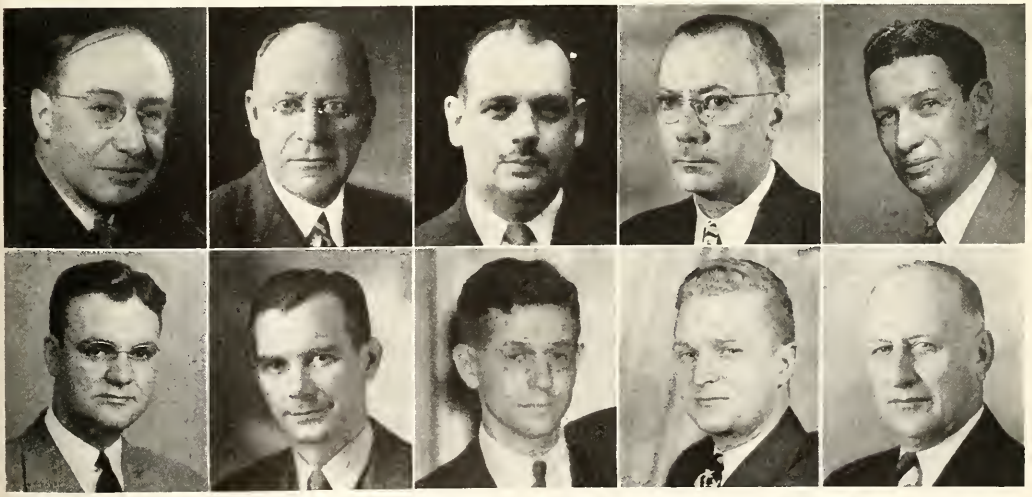
Earl J. Smith, Engineer, Underwriters' Laboratories, Inc.

W. Z. Whipple, Chief Engineer, Chicago Eye Shield Co.

After several meetings of this committee, the intent of the Fire Protection and Safety Engineering Group in the Western Society of Engineers has been developed in the following statement of purpose:

> The purpose of the Fire Protection and Safety Engineering Group of the Western Society of Engineers is to promote and coordinate the science and methods of fire protection and safety by indicating those safeguards that will prevent loss of life and property, and to attempt to bring this information to the attention of personnel in all fields of engineering.

Plans have been laid for future programs which will embrace a subject regarding safety engineering during February to be followed by a fire protection program during the third week in March. The closing program of the first half of 1946 may be a combined safety and fire protection program that will be conducted on the basis of a forum, if arrangements can be made and accommodations can be secured before that time.



TOP ROW, *reading from left to right*: *James I. Banash, J. B. Finnegan, John D. Gallagher, W. Z. Whipple, J. E. Harrington.*
BOTTOM ROW: *John Ahern, Herbert W. Lange, Art Jens, Bolton Anderson, W. J. Fairbairn.*

Our Future Engineers

A Problem of Supply and Demand

By

HARRY MCCORMACK

There are disturbing questions in the minds of all of us connected with the engineering profession as we contemplate the future.

These questions are related to:

(a) The supply of young men and perhaps women preparing to practice in the various lines of engineering.

(b) The educational training of these young people that they may possess a basic understanding of the practice of their particular line of engineering and be technically competent to engage in it.

(c) The extraneous conditions surrounding all of us in our future engineering practice.

It is questionable, in my opinion, as to whether the best "raw material" flows to the engineering schools to be prepared for professional practice.

You as practitioner and I as a teacher of engineering, are at least partially to blame for this in that we have not exerted ourselves to see that more specific information is supplied to our young people about what is involved in the practice of the engineering professions.

Contact with students in one line of engineering over a period of forty years convinces me that they reach the decision to prepare themselves for an engineering profession having only the most vague ideas of the necessary preparation, as well as of the activities, duties and responsibilities involved in their future engineering practice.

They do not know the lines of industry where there are possibilities for their employment, the specific things they may be asked to do should they secure such employment nor what would be the average remuneration in such a position.

Such information is available, not as definite and complete as it could be, but reasonably satisfactory. There is available a publication by the Engineering Counsel for Professional Development which should be read and considered by the engineer who has in his mind the prospect of being able to assist young men contemplating a collegiate career followed by a professional one.

There are certain general references which should be in every library and to which every young man contemplating an engineering profession should direct his attention. These are:

"Vocational Guidance in Engineering Lines" by Wadell, Skinner and Wessman.

"Engineering Opportunities" by R. W. Clyne, directs attention, in the main, to such subject matter as the title would indicate. Opportunities for the young man are the various lines of engineering.

"The Engineer" by John Hayes Hammond contains ideas on various engineering projects and in the main gives some information as to how they may be carried out.

"The Story of Engineering in America" by Chelsea Fraser is a general account of the development of engineering in this country and is interesting reading, but does not answer many of the questions in the mind of the young man.

It was of interest to me, when I took these books from our library shelves, to note how often they had been withdrawn, as indicative of how much they had been read. "Vocational Guidance in Engineering Lines" had had twenty-two readers during the period, May, 1943 to September, 1945. "The Engineer" had had no readers between October, 1943 and September, 1945. "Engineering Opportunities" had had twenty readers in the period between August, 1943 and September, 1945.

The most satisfactory and complete analysis covering any line of engineering was prepared by a committee of the American chemi-Chemical Society and it covers an analysis of the economic status of the chemist and the chemical engineer. This is published in Chemical and Engineering News, Vol. 22, numbers ten to thirteen, inclusive.

This covers rather completely all of the items in which the prospective chemical engineer might be interested, such as graduate and under-graduate training, lines of employment, salaries, at various training levels. It also enumerates the number engaged in chemistry and chemical engineering.

The fault of all these general publications, together with that cited from the American Chemical Society, is that they leave the young man guessing as to just what he may be asked to do in the various positions which may be open to him. This, of course, is something in which he is intensely interested and it is regrettable that there is no source where he may obtain such information. It seems that the responsiblility for getting such information to the young man comes back clearly to you and to me, through personal contacts with the young man, conveying this information to him. For example: A young man may be engaging in research or development work in some engineering line. Just what does he do? What is involved in doing research work, and what is involved in doing development work? What particular qualifications do these lines require other than those possessed by the average practitioner of this particular type of engineering?

My opinion is that the young engineer has his mind filled with the glamour attached to certain lines of engineering. He does not realize just how much hard work is required in the preparation for engaging in these "glamour" phases of engineering; nor does he at all realize how much hard work is involved in these lines and how little glamour actually is attached to them, solely the glamour of accomplishment.

Predicting the future from past experiences, I expect to find our departments of electrical engi-

neering overcrowded with young men who want to engage in the applications of radar; and our departments of chemistry and physics over-loaded with young men who want to learn how to make atomic bombs.

The young man can not be relied on to search for, find and use this information himself, so there are some duties for you to assume: See that your Juniors in High School hear about the engineering professions, tell them what engineers do and be sure to tell them the joys accompanying the doing, tell them, truthfully, what the remuneration is likely to be, how important the work is with reference to our daily life, and tell them where they can obtain additional information should they be interested. It would be excellent for you to say that you would spend the time to talk with them about an engineering education.

Be sure that your local library has a file of the publications previously mentioned.

It is hoped that you are now considering the advisability of having a committee on professional education as one of the permanent committees of your local engineering organization. There is much valuable work for it. You can reach these young men and help them because they are your neighbors and they have confidence in you.

Last, but not least, tell them that there are engineering schools and engineering schools and that they are most likely to receive the most for their effort when attending a s c h o o l having E.C.P.D. approval.

Don't misunderstand me here. Many excellent engineers have graduated from mediocre schools, but only God knows how much better they would have been had their preparation been better.

Suppose all these ideas have been acted on, the young man reacts favorably; do we succeed in enrolling him in an engineering school?

Not if he is in the age limit 18-26. We live under a so-called Selective Service Act. Justification for the use of the word selective would be difficult on the current interpretation of the act, though its Congressional sponsors must have had some vision of selectivity when giving the act its title.

As applied today, any young man reaching the age of 18 and who is sound physically is in the armed forces. We have not shown as much sense in this respect as have many of our allies.

During the past six months, I have talked with educators from Australia, Canada, England and Russia in regard to the exemption of the talented young student. The opinion expressed by all of these men was: "You are making the same mistake we made in World War I; we are not making it now. Students with ability are exempt." In addition to my own experiences in talks with educators from other countries, "Chemical and Engineering News" in the issue September 25, 1945, has these statements: "Many directors of research who were interrogated in Germany said that in their opinion a major factor in the loss of the war was the early drafting of their young chemists and physicists. Documentary evidence was obtained that in 1943 the German authorities saw the seriousness of the situation and stopped the drafting of such men."

Present indications are that we are going to continue our short-sighted policy for some years to come.

Our shortage in engineer production in the past five years has been between 35-40,000 and the probability is that this will continue at the rate of about 7,000 per year for the next four years. The Bush Report, prepared at the request of the late President Roosevelt, gives much higher figures than my own as to the shortage in engineer production and higher figures also as to the rate at which this shortage will continue.

All the engineering societies are deploring the conditions which are bringing this about, but their voice is as one crying in the wilderness.

It is a deplorable state of affairs and should be remedied. How bad it is is emphasized by this opinion: If we had had a Selective Service Act in 1925, administered as it is today, there would have been no millions of units of blood plasma, no tons of penicillin, no hundreds of tons of D.D.T., no hundred thousands of tons of synthetic rubber, no rivers of high octane gasolene, no B-29's to use it, and no atomic bombs, because our supply of research and development engineers would have been so restricted at its source that there would not have been available sufficient talent to have developed these things.

Projecting this into the next decade, this is a dark picture.

What can we do about it?

One suggestion is that we come out of the wilderness to do our crying and that at every opportunity, we express our opinions of present conditions in no uncertain terms.

The industrial future of our country can be assured only when there is an uninterrupted flow of "raw material" to our engineering schools.

Assume that thru some methods, such as those presented, or some better ones not yet visualized, the embryo engineer has been induced to enroll in some engineering school; What is to be his course of study? This, to one in the teaching profession is an item of major importance.

What does a professional engineer need to know to make a living? What related subjects are likely to assist him in making a better living? What sequence of courses leads to the most orderly and profitable advance in his professional achievements?

These are questions that must be answered as one builds an engineering curriculum and the correctness with which they are answered determines the value of the curriculum.

The standard curriculum has been one of four years, during which the student is in school about 36 weeks per year, and the remainder of the time "on vacation." This has been the set-up for the past hundred years. It has taken no cognizance of the remarkable expansion in technological information which has happened in this period. Great grandfather went to college this way, therefore, its good enough for Sonny.

Some of us think this allotted time is too short and we are not thinking in terms of the time necessary to teach an engineer all he needs to know.

We are thinking in terms of the time necessary for laying the firm foundation upon which he may build for the remainder of his life.

It is thought that you will not be interested in the specific items entering into this proposed course of study, but it is believed that

you will be interested in the general objectives in mind when it was formulated. These were:

Introduction of some engineering and something of the engineering concept early in the course.

Make every possible course a course in English composition and in public speaking.

Include some courses in history, public relations, business procedures and modern language other than French and German.

Make a substantial percentage of the subject matter elective, 30 semester hours out of a total of 170, so that the young man can choose lines of study in which he has the greatest personal interest.

Having these statements before you, do you longer question the soundness of asking for a longer time?

The curriculum, as proposed, is composed of eight semesters of 18 weeks each, these will coincide with the customary collegiate year. In addition, there will be three summer terms of 10 weeks each.

There is an analogous division of subject matter, the customary general material of an engineering course in the 8 semesters, while the more specialized subjects will be presented in the 3 terms.

This has been visualized for chemical engineering, but no reasons are apparent which make it inapplicable to any or all engineering curricula.

The completion of such a course is believed to be a satisfactory foundation for the student, should he decide either to continue in graduate work or to engage in the immediate practice of his profession.

Certain scholastic achievements must be met before the student is permitted to elect this course and certain other scholastic requirements are necessary for him to remain in the chosen course.

Physical training is required during each semester and each term.

The speaker is a firm believer in the doctrine of "A sound mind in a sound body."

The student would graduate knowing something, not too much, about his profession and about the world in which he will have to practice it.

The major part of his education regarding these extraneous conditions is yet to come. He must face this with resolution and with an open mind. His behavior with respect to these things will, in the main, determine whether he will become a great engineer or only a mediocre one.

Some suggestions for this post collegiate training are offered, without specific applications.

He should have a part in the civic affairs of the locality in which he lives.

He should be a member of an engineering society in his particular line and should take a part in its activities, not limit his endeavors only to paying his dues and reading the society publications. his is better than nothing, but is not enough.

It is believed that much of the onus for lack of interest on the part of members can be ascribed to the customary way in which the various engineering societies are operated. They meet, on stated occasions, for the presentation of scientific papers, many of them of value, but very few of them ever leaving us all hot and bothered about something which we think we should do.

Possibly a few meetings devoted to the discussion of these things affecting our professional status and development might stimulate interest among the membership.

Some meetings of this type have been attempted, but in the main they have been failures because we can't or won't talk.

What makes us this way can not be explained. Certainly there are enough things being done or which someone is contemplating doing which vitally affect all engineering practitioners to afford ample material for discussion.

Chemical and Engineering News published in the August 25th issue the essential portions of the report of Vannevar Bush to the late President Roosevelt, "Science—The Endless Frontier", and summarized in the September 10th issue various bills affecting research and industrial development which Congress will consider in the near future. "Every scientist should study with care the Bush Report and the proposed measures. Three of these bills are identical and embody the basic proposals of the Bush Report. Others go much further in the degree of control, direction, and supervision of research given to government and contain a very different type of philosophy on the relationship of government, research, industry, science, and scientists. It is the duty of chemists and chemical engineers to express to their Senators and Congressmen their considered opinions of a program that represents in many ways a decided departure from the past and that will have a profound effect on the whole future of research. Can we afford to remain silent when not only the future of our country is at stake but the future of every scientist is involved? Now is the time and the opportunity of demonstrating to Congress and to America that scientists can be a potent constructive force to be considered seriously when legislation affecting the future welfare of our country hangs in the balance."

The release which accompanied the H. D. Smyth report of the record of the development of the atomic bomb stated that, "The best interests of the United States require the utmost cooperation by all concerned in keeping secret now and for all time in the future all scientific and technical information not given in this report or other official releases of information by the War Department." The Chemical News says: "If we read and interpret this statement correctly, it is the intention of the Army to become the sole censoring authority of all research information and data on nuclear physics. We earnestly hope that no such authority is vested permanently in our Army officials, and that future research is not directed and controlled by the Army. Certainly a High Command which forced thousands and thousands of scientists into the Armed forces instead of retaining them in research and production, a High Command that has denuded our colleges and universities of teachers and bone fide students in scientific courses, a High Command that has robbed America of a whole generation of future scientists, and one that has steadily refused support of the aims and purposes of the McDonough Bill, has demonstrated with any such authority or power over postwar developments in atomic energy."

An editorial recently published

(Continued on page 38)

Alice and the Slide Rule

Engineers Can Dream Can't They?

By

L. A. Hawkins and Sanford A. Moss

Alice was sleepy. She was tired from pushing a slide rule all day, making calculations on a strange thing called jet propulsion. Her profession—a new one for girls—was making engineering computations.

But Alice was sleepy. Her thoughts of slide rules and figures seemed to blur and become meaningless; and they escaped from their difficult task and fled, as they often did, across the Atlantic to her happy childhood home in England. She liked her name, Alice, for, as far back as she could remember, her favorite heroine had been that other Alice who had those marvelous *Adventures in Wonderland* and *Through the Looking Glass*. She had liked to think of herself as Alice, Jr. Later, at Oxford, her studies of mathematics and physics gained extra zest from the thought that she was following directly in the footsteps of the master, Lewis Carroll, whose whimsical brain had given birth to her heroine. Then she had been projected across the ocean to apply her mathematics to the feverish war work of Britain's great American ally.

But now it was not to an England torn by bombs that her sleepy thoughts turned, but to a peaceful England where whimsies of white rabbits led little girls to confusing but delightful adventure. Suddenly her wandering mind was recalled to her room, which had become strange. Beside her sat a man whom she dimly recognized as her engineering supervisor, but whose huge hat and de-intellectualized features revealed him clearly as the Mad Hatter himself.

"Alice, Jr.," began the Mad Hatter, "your work is seriously defective. You should make that computation in slugs."

"But," said Alice Jr., "a slug is a slimy thing like a snail, that eats cabbages."

"Well," said the Mad Hatter, "some people say this kind of a slug is slimy all right, but it isn't like a snail. It is what you get (if you use pounds-force, feet and seconds) when you divide weight by gravitational acceleration. This is W divided by g and tells how much mass you have. I suppose we could define mass with any units of force and length, but most people use pounds-force and feet and seconds and get slugs".

"We never learned that in England," said Alice. "We learned that mass was the muchness of anything, like how much sugar you get for sixpence and a ration stamp, and often we called it *weight* instead of mass. I think of muchness as meaning quantity of matter, which is the same, or nearly the same, as inertial mass. And when you say 'gravitational acceleration', I suppose you intend to include the very tiny centrifugal force due to the earth's rotation, and really mean net acceleration."

"Yes, of course," said the Mad Hatter, "if you want to be particular. But your first statement was wrong, weight is not mass, but is gravitational force on a mass."

"Well," said Alice Jr., "you can tell the muchness or mass of anything by weighing it on beam scales against standard chunks of mass that even you call 'weights'. When my mother wants to see if she is getting too fat, she does this and she calls it her weight. I am sure it tells her how much is inside of her, and has nothing to do with the actual value of gravitational force. Besides, a groceryman who lives high up in Mexico City, not far from the equator, or who lives in Canada near sea level, or even grocerymen on the moon, if there are any, will sell the same muchness and sweetness for a pound of sugar, by weighing it against the same 'weights' on a beam scales, and I know the gravitational force that you want to call weight, is quite different. So what you call the weight of a 'weight' doesn't tell you much of anything. But you can tell the mass in pounds just by looking at the numbers stamped on the weights, without the extra bother of thinking about force and acceleration and what you call weight."

"Well," snapped the Mad Hatter, "when you weigh a thing against weights, you can't call the muchness weight, you have to call it mass."

"All right," said Alice, "I won't say weight any more, but will say mass instead. But lots of people don't know that you call gravitational force 'weight', and they think weight means mass. So you'd better stop using your ambiguous word 'weight', and say 'gravitational force' instead. But what has that got to do with slugs? I'm always used to measuring mass in pounds, as I've said already."

"No," said the Mad Hatter, "you've got to think about slugs. A pound-mass is just like a slug, but is about a thirty-twoth of it."

"Now you're getting us all mixed up," said Alice Jr. "Even if we are going to use the word mass instead of weight for muchness, when my grocer has a pound-weight on one side of a beam scales or balance, and some sugar on the other side, and they balance, why can't we call it a pound of sugar? Then we don't even need to mention weight or slugs or W/g."

"Oh no," said the Mad Hatter, "you've got to measure muchness in slugs."

"I don't know why," said Alice. "You can't say that W/g in slugs is the only unit for mass. Chemists in England and America measure muchness in pounds, which I am willing to say is the pound-mass instead of the pound-weight. Mechanical engineering handbooks talk about 480 pounds of iron in a cubic foot, and so many pounds of wire per 100 lineal feet and all that. Industry and commerce in the United States and Great Britain really are based on the pound-mass. The chemist's pound-molecule is based on the pound-mass. Whoever heard of a slug-molecule?

The international standard of mass isn't a slug; it's the International Prototype Kilogram, and there is a copy of it in the National Bureau of Standards. The standard pound-mass is defined by United States law as a specified fraction of the kilogram, and a representation of this also is kept by the Bureau of Standards.

"Then any pound-mass is what balances a replica of this chunk of muchness called the standard pound-mass, on a beam balance, anywhere at any altitude, on earth or moon.

"It has been proved once and for all that this gives inertial mass, so we don't have to stop and confuse ourselves every time we use a beam balance, or write an equation; by supposing that we are measuring gravitational force, or what you call weight; or by slugs. A standard pound-force is how much this pound-mass is pulled at any place where there is the International standard value of gravitational acceleration, 32.1740 ft/sec^2.

"Everybody was happy when we used to talk about poundals, and then force in poundals was mass in pounds times acceleration, or F equal ma. But if we want to use the pound-force, which is about 32 times as big as a poundal, we can keep the same equation, with the pound-mass that is used in everyday life, and put a pure number—about 32—in the denominator on the right, because the force unit gives a numerical value which is about 1/32 of the value in poundals. We may define this denominator as a pure number, equal to g, the absolute value of the International standard value of g, and use it in the equation $F=\frac{W}{g}a$, without any complications about gravitational forces or slugs. Some precise people call this gc. We have exactly the same numbers to work with and the same arithmetic as you do with slugs and the equation $F=\frac{W}{g}a$, without the fogginess of this new and high-brow slug, and as I said before, without having to decide whether W and g are standard or local values and without thought of your concept of weight. Frenchmen do the thing with the kilogram-force and kilogram-mass. Nobody wants to think of a metric slug."

"Well," said the Mad Hatter, "if you are going to work with the aerodynamic people, I keep telling you that you can't measure mass in pounds any more and have got to measure it as some of them do, as the quotient of gravitational force and gravitational acceleration."

"That sounds like jabberwocky to me," said Alice. "A pound-mass is a pound-mass, whether it is on the moon or anywhere. Do you know the gravitational acceleration on the moon?

"If you want to compute the forces and accelerations on an airplane at 60,000 feet, you can't say that the gravitational force and acceleration, which your W and g explicitly mean, are practically the same as at sea level."

"But the mass in slugs doesn't change with altitude," said the Mad Hatter, "because the weight and the gravitational acceleration change in the same ratio. And when we use in the equations W and g that explicitly mean actual values, we don't intend that at all, but do intend standard values, *Ws and gs*."

"Then it's silly to use W and g," said Alice. "You put in their values that everybody knows are variable, and whose ratio in some units people call slugs, and then you say you don't need the actual values after all. So it's simpler to stick to the pound-mass and the standard pound-force that you know have the same value at all altitudes, instead of using W and g, both of which vary. Then you can use the actual value of gravitational acceleration at high altitudes when it is needed for computation of airplane accelerations.

"All the thermodynamics people that I know talk about a pound of working substance. If you keep on talking about slugs, I suppose next you will want to have me talk about entropy of a slug."

"Why, of course," said the Mad Hatter, "Newton's second law says that force is equal to mass times acceleration, and the only way you can follow Newton is to measure mass in slugs, even with entropy."

"I was told that Newton's second law doesn't say anything of the kind," replied Alice Jr., "but that he said—in Latin—that force was *proportional* to mass times acceleration. So in Newton's Second Law I can, as I said, measure force with the standard pound-force and muchness with the pound-mass, by putting in this proportionality factor with no dimensions, whose numerical value is that of the standard g. I still think that's a lot simpler than having to think that mass is gravitational force divided by g. Why, some of the people who do this are so ashamed of it, that they won't even call it a slug, but just say it is a unit of mass. Other people give more confusion by calling it a gee-pound. But I am going to stick to the good old pound as the unit of mass, just as the grocer does. There was a chunk called the standard pound, in England, maybe before the Pilgrims landed in America, and sealers of Weights and Measures and Bureaus of Standards in both countries have equivalent chunks to this day. It is much simpler to think of mass as something measured by comparison with these standard chunks, than as being the quotient of W and g. And if you do this, you don't have to introduce your concept of weight at all in talking about mass. And as for entropy of a slug, entropy is hard enough to understand, anyway, without having to mix up slugs with it. All the steam tables and ammonia tables give entropy per pound of muchness. Who wants to have all the steam tables done over in slugs? So mechanical and chemical engineers now working on jet propulsion, all of their lives have measured the working substance and the values of entropy, enthalpy, and heat of combustion, all in terms of the pound-mass as the unit, and so does Professor Keenan's new book on *Thermodynamics of Air*. The plane builders get the mass of the plane in pounds, and the pound-mass and standard pound-force are perfectly good units to keep on using when the thrust on the plane is being computed. The Wright Brothers and their successors who started building airplanes were mechanical engineers. Practically all calculations of mass flow of air are connected with the airplane power plant—the mechanical engineer's province—so airplane calculations should be made in the mechanical engineer's units. Students in colleges have been befuddled for years because machinists, grocerymen and their professors of thermodynamics and chemistry use the pound-mass, while their profes-

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The Five Year Gap

And The Answer Is Here

By

R. C. KINTNER

Ten years ago an automobile hurtled through the hills of central Pennsylvania. Five men were in a hurry to get from college town to college town on a very serious errand. The party, made up of an assistant director of research, a general superintendent, a general plant manager, a district sales engineer, and a personnel manager, was in earnest pursuit of college graduates of engineering and physical science curricula in eastern colleges. Their organization, one of the largest corporations in the land, had suddenly awakened to the realization that there was a *five year gap in the company's technical personnel.* A few, but only a very few college graduates had been added to the staff since 1929. There was not enough work to occupy the time of those on the payroll and for over five years, the attitude had been to refrain from hiring more. Little effort was made to retain those who were already in the organization during those fateful five years. But, in 1935, the company came to the painful realization that, although there was an abundance of men in the intermediate positions being trained for upper level responsibilities, there were almost no young graduates being trained for the intermediate jobs. This would lead to a sort of scientific anemia in an industry that depended on a constant infusion of scientific brains for the continuous operation of its production and research work. Hence, the sudden and energetic scouring of the eastern universities in search of the brightest young men that could be found.

"Never again", they declared, "will we permit such a situation to develop. We will always hire our quota of college graduates every year, depression or no depression."

Today that same corporation has, through no fault of its own, another "five year gap". Very few graduates of engineering or science curricula have been available to industry since December 7, 1941. Many of those who were temporarily available were taken into the armed forces. The situation is more serious this time. They cannot put five key men into a seven-passenger sedan to race from campus to campus to search for the most promising engineers, chemists, and physicists, in sight. There is not now, and for four more years there will not be enough such men graduated from our universities and colleges. The "five year gap" may well turn out to be a ten year gap, though the action of Selective Service on November 30, 1945, may allow a trickle of such young men to graduate during the next few years. Such a lack of new brains might be almost fatal to a competitive industry based on continuous research and development.

There is one hope that such industries hold. The returning veteran may be able to fill the gap. He is in the correct age bracket, has the correct poise, is interested in getting ahead, and he is being helped to aatain his educational desires by the Veterans Administration. Based on his degree of training at the time of discharge he falls, for purposes of this discussion, into 3 main groups. He may have been graduated from high school and been swallowed by "Selective Service". Perhaps he entered college and was able to obtain one, two, or three years of education in his chosen field of science or engineering before Uncle Sam called him. He may have been able to graduate with a baccalaureate degree. In any case he wants to finish the next stage of his training, with perhaps a little review work to get properly started.

The "G. I. Bill of Rights" is a wonderful means of attaining the end sought. It gives him $65.00 per month, if single, or $90.00 per month, if married, plus necessary educational expenses such as tuition, books, etc., up to $500.00

Now $90.00 a month with which to pay rent and buy groceries, clothing, transportation, and a hundred other items, is one thing in a sleepy little college town and something quite different in Chicago, New York, Washington, or Detroit. In any of these cities, the $90.00 of amended House Bill 346 for a man and wife (and perhaps a child or two, as well) will permit them to live but little above slum conditions. Unlesssome other source of income is some other source of income is available, the returning veteran may not be able to go to the school of his choice. He may have saved somethings from his service pay or his near relatives may be able to help him through college as they would have done if he hadn't gone to war. But he didn't have a wife and child then.

Many ex-service men have two desires in their mind. They have greater or lesser doubts about the state of their knowledge as equipment in a civilian world. They suspect that they may be rusty on mathematics, physics, chemistry, or engineering. They feel the need of "brushing up" on these and would like to get a little more advanced training. They also want this period of training to be a bit short or to do it while working. Because they are from two to five years older than when they left school or a job, they want to get along on the path to a career.

Several plans have been evolved for meeting the needs of the employer with the "five year gap" in his personnel and of the returning veteran with his desire for education that will not take too many months to complete. Each of them, with variations, can be adapted to meet the needs of the man with no college credits, with a part of his four or five year curriculum accomplished, or for the college graduate of high scholastic ability who wishes to pursue graduate work. Most educators feel that only men who graduated among the

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Midwest Power Conference

Palmer House, April 3, 4 and 5

By

STANTON E. WINSTON

Professor Winston, professor of mechanical engineering and director of the evening division at Illinois Institute of Technology, is the only person to have been closely associated with the Midwest Power Conference since its conception as a cooperative institution in 1938. *For the past six years he has served as conference director, and will hold that position once more for the* 1946 *conference.*

With the removal of restrictions on group meetings by the Office of Defense Transportation, the Midwest Power Conference will resume its annual meetings with a conference on Wednesday, Thursday and Friday, April 3, 4, and 5, 1946, at the Palmer House in Chicago. It will be noted that this conference is to extend through three days, in order to permit the inclusion in its program of the large number of subjects in the various fields of power that are of current interest.

The Midwest Power Conference is sponsored annually by the Illinois Institute of Technology with the co-operation of nine other midwestern colleges and universities, together with six local sections of national engineering societies, the Western Society of Engineers, and the Engineers' Society of Milwaukee.

The University of Illinois, University of Michigan, University of Minnesota, University of Wisconsin, Northwestern University, Purdue University, State University of Iowa, Iowa State College and Michigan State College make up the group of co-operating educational institutions.

The six professional groups are: Chicago Section, AIChE; Chicago Section, AIEE; Chicago Section, AIME; Illinois Section, ASCE; Chicago Section, ASME; and Illinois Chapter, ASH and VE. The success of the conference is due to the splendid co-operation of all of these institutions.

The preliminary program of the 1946 meeting is at present being formulated by Stanton E. Winston, conference director, with the collaboration of representatives of the co-operating universities and engineering societies. Professor William A. Lewis, of the Institute's electrical engineering department, is arranging and coordinating the four electrical sessions of the program, while Professor John T. Rettaliata, of the mechanical engineering department, is functioning in a similar capacity in setting up two sessions on gas turbines.

In addition to these electrical and gas turbine sessions, and the popular opening meeting, it is anticipated that the program will include sessions on atomic energy, industrial power plants, feedwater treatment, developments in space heating, developments in air conditioning, fuels and combustion, central station practice, Diesel power, and hydro power.

The program will again feature joint luncheons with the American Society of Mechanical Engineers (12:15 p.m., Wednesday, April 3), and the American Institute of Electrical Engineers (12 p.m., Thursday, April 4), as well as the main event, the All-Engineers Dinner at 7:00 p.m., Thursday, April 4. A third luncheon will be held at noon on Friday, April 5. It is hoped that such an array of sessions and events will make 1946 a banner year for the conference.

Kindly remember that everyone interested in the field of power and in the nation's power problems is cordially invited to attend the conference. You should not miss this national power forum. Your attendance and participation in this, your conference, will help to make it a success. Place the date on your calendar NOW, and make your reservation at your favorite Chicago hotel as soon as possible.

All inquiries with respect to the conference may be addressed to Professor Charles A. Nash, Conference Secretary, c/o Illinois Institute of Technology, Chicago 16, Illinois.

PRELIMINARY PROGRAM

Wednesday, April 3, 1946

9:00 A.M. Registration, Palmer House.

10:15 A.M. Opening Meeting. Chairman: L. E. Grinter, Vice President, Illinois Institute of Technology.
- (a) Address of Welcome, James D. Cunningham, President, Republic Flow Meters Co., Chicago.
- (b) Response for the Cooperating Institutions. T. R. Agg, Dean, Division of Engineering, Iowa State College.
- (c) Atomic Energy. P. W. Swain, Editor of POWER, New York.
- (d) Future Requirements and Trends in the Use of Electric Power. Howard P. Seeyle, Senior Engineer, Detroit Edison Co.

12:15 P.M. Joint Luncheon with A.S.M.E. Chairman: J. C. Marshall, Chairman, Chicago Section, A.S.M.E. Speaker: Alf Kolflat, Partner, Sargent and Lundy, Chicago. "Problems in Power Plant Design."

2:00 P.M. Central Station Practice. Chairman: P. F. W. Waller, Jr., Chairman, Power and Fuels Division, Chicago Section, A.S.M.E. (Sponsored and arranged by the Power and Fuels Division, Chicago Section, A.S.M.E.)
- (a) Automatic Control of Steam Generators and Auxiliaries. P. S. Dickey, Chief Engineer, Bailey Meter Co., Cleveland.
- (b) Arrangements Pending.
- (c) Discussion.

2:00 P.M. Developments in Air Conditioning. Chairman: James S. Locke, Minneapolis-Honeywell Regulator Co., Chicago.
- (a) Centrifugal Compressors. W. H. Carrier, Chairman of the Board. Carrier Corp., Syracuse.
- (b) Cooling Tower Selection. J. Lichtenstein, Foster Wheeler Corp., New York.
- (c) Discussion.

3:30 P.M. Feedwater Treatment. Chairman: C. H. Fellows, Detroit Edison Co.
- (a) Problems in Water Conditioning in Plants Using High Percentages of Makeup. Leo F. Collins, Chemical Engineer, Detroit Edison Co.
- (b) Arrangements Pending.
- (c) Discussion.

3:30 P.M. Recent Electrical Developments. Chairman: J. S. Gault, University of Michigan.
- (a) Transmission-line Fault Locater

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Training for Battle

As The Navy Did It

By

LINCOLN MAYTHAM

Although my background is not that of the professional trainer or educator in any respect, my interest in this subject probably was born of the fact that while I was with the fleet we received a large number of men who had completed their "boot" training or recruit training and the natural result was that I began to think about the way I would conduct their training if I had the chance. Over a period of time, it finally resulted that I was given a mapor responsibility for the policies and operation of one of the largest basic training activities in the world and then I had a chance to find out that it wasn't as easy as I had thought it would be.

I think now that one of the best lessons to be learned from some of the training methods we used in the Navy is what not to do.

Admittedly there are many instances of poor coodination in our Navy training. I am sure that many persons read the story in the November 3rd issue of the Saturday Evening Post entitled "This Ain't No Taxi" by Robert M. Yoder. It's a story about a young Ensign, Hawley, who was green as grass. The Navy had given him a liberal education in engineering and some other technical subjects and then they took him right out of that training and put him in command of a small Man-of-War. He'd never seen a Man-of-War, had never seen an ocean, and his crew had never been to sea.

His misadventures undoubtedly are more than hilarious to readers of the Saturday Evening Post but in some respects they verged on being tragic to the Navy, until he got the feel of what he was doing. Then I believe, if the story is accurate, he was one of the most valuable small boat skippers that the Navy had. However, the process of reaching this point was very painful and perhaps somewhat expensive. An old time Chief Petty Officer later told Captain Hawley that of all the Naval Reserves he ever saw, Hawley was the most Reserve.

Well, as a matter of fact, there is no fault that can be attached to Ensign Hawley in any respect. It was simply a case of his having been put into a job of work for which the Navy had given him no training.

On the other hand, in certain fields of Navy training, the methods used have been most effective and efficient. Outstanding in this respect is the field of pilot training. Where the lives of the trainee or the instructor or both were at stake you were likely to find a high degree of efficiency and intelligence in the training methods. This was true also in the submarine field, and others.

Then you'd find many specialized fields in which some energetic, intelligent officer had developed advanced methods and equipment for training. An example of such a field is the series of Combat Information Center Officers' Schools which were established throughout the war in various places in the world. I happened to have the good fortune at attend such a school on an island in the Pacific and I think I got more out of my few weeks training there than any other training that was given me in the Navy. In this school the training equipment used was most elaborate.

It was perfectly tuned to the exact conditions which would be met while at sea and in combat.

Now the C. I. C. Watch Officer literally has the ship in his hands when his ship engages in combat at night or under difficult conditions of visibility. He is in an enclosed space in the heart of the ship where he can't see a thing excepting by means of his instruments; but with his instruments he can see and plot what's going on throughout the area, in respect to other ships, aircraft and enemy attacks, far more accurately than a large staff could plot it in broad daylight without the help of these particular instruments.

In this school the officer students were broken down into groups of three officers each, one representing the Captain of a ship, the other representing the C. I. C. Watch Officer and the other representing the Radar Plot Officer. The school was equipped with large plotting boards placed at great distances from each other, but each plotting room was equipped with complete communications systems such ar you would have on board a ship. Each plotting board, also, was rigged so that all information regarding all other ships that would be available in the Combat Information Center at sea would come to it.

The various groups of officers representing ships were broken into two parts so that one group would represent the friendly task force and the other group would represent the enemy.

Actual battle conditions were duplicated as closely as it was possible to do. To lend reality to the situation, battle noises were played through an amplifier and enlisted men, stationed in various parts of the school, pounded on large pieces of sheet iron with sledge hammers to simulite gun fire and bomb explosions, and to make as much noise and confusion as possible.

Each designated captain was required to fight his ship, giving orders for simulated courses and speeds, gun fire, and torpedo attacks, and doing everything else exactly as he would have to do under combat conditions, plotting his movements on charts of the area in which the action was presumed to be taking place.

Everything he did was relayed electrically to a master plotting board where the referees kept track of all ships' movements and all actions taken by all Captains both in the friendly force and in the enemy force. They even plotted out the course and speeds of torpedos and estimated the probable damage caused by a simulated torpedo attack and all

other actions taken. When it appeared to them that any one ship had suffered enough damage to sink it, they would put that ship out of the running.

These sessions were conducted two or three times each day and in that way, the Student Officer got more practical experience in fighting a ship from instruments than he posisbly could have acquired in several years' time in the combat areas.

Another field in which most effective training methods were employed was in the instruction of recognition of airplanes and surface craft. This was done in a most efficient manner with carefully thought out equipment intelligently used. The result was that men in the Navy generally became more expert in recognizing aircraft and surface craft of all nations than the average small boy is at recognizing makes of automobiles or airplanes that fly around his home. In this training, moving pictures, sound pictures, exact models of the airplanes and ships, charts, and other things were used. I am sure that many of you are familiar with these things because many of you studied aircraft recognition whether you were in the service or not.

One of the most effective means of instruction in the Navy is the use of sound movies.

The same thing is true, perhaps to an even greater degree, in the Army. We used many Army educational films in the Navy and many of them were superior to our own.

Another excellent device is what we called the "flag hoist trainer" with which Signalmen were trained to communicate from ship to ship by the use of signal flags. The "flag hoist trainer" is a cardboard duplicate of what is called the "flag bag" on board ship. The "flag bag" is a large area on the communications platform and the "flag hoist trainer" contained all the flags and hoists on which to fly the identical signals that would be used at sea. We'd set up these trainers on shore or on the ship at a distance one from the other and in an amazingly short time the Signalman would become more than expert in communications by this means.

Then we had the Link Celestial Navigation Trainer and small planetariums, which were most effective. The Navigator or prospective Navigator would be placed inside a small planetarium under exactly the same conditions in which he'd find himself if he were navigating an airplane at night. All of the navigational stars would be shown on a dome overhead and their positions on the dome would be slowly changed to simulate the changes that would occur as an observer moved from one place to another in an airplane at high speed. He would have to take sights on them, figure his positions, and do many difficult problems in navigation. After a short period of this kind of training he would be a most expert navigator, probably far sugerior to the average navigator in the Navy or the Merchant Marine before the war. Unfortunately, only a very limited number of navigators were given this kind of training. Generally speaking, the surface ship navigation training in the Navy has not produced expert navigators to anything like the degree that was accomplished by the use of the method I have just described.

Another excellent field of training was our training in fire fiighting. Fire fighting schools were set up all over the world and the greatest accomplishment of these schools was to eliminate any fear of fire from a man's mlnd. We built tremendous gasoline and oil fires at these schools and then put the men out there with good equipment and told them, "There it is boys, put it out". They soon learned that if they had the proper equipment and if the equipment were functioning, no fire was too great to be controlled in very short order.

We also used excellent training methods in anti-aircraft firing. Right out here at Great Lakes we had one of the finest anti-aircraft ranges in the world. We gave the men an intensive training in anti-aircraft firing with 20 m.m. and 40 m.m. guns. We gave them little drones or radio-controlled airplanes to shoot at. We burned up more ammunition out there in a day's time than it probably would have taken to fight a major battle of the Civil War. As a matter of fact, I don't think there is any country in the world that is rich enough to conduct for very many years the kind of training in anti-aircraft firing that the U. S. Navy conducted during this war. If my own mathematics on the cost of ammunition are correct, the ammunition that was burned up in practice alone would break any Treasury in a comparatively few years.

Some of the fields in which less effective training methods were employed were pretty important fields. I would throw small arms training into this classification. The training in the Navy in small arms left a great deal to be desired. We would have our men shoot something in the neighborhood of 100 rounds of ammuinition and then consider them trained in the rifle or pistol. I happened to be talking with a leader of the underground in Denmark the other day and he told me that every member of the underground was required to fire at least 2000 rounds of ammunition and he wasn't released from the training until he had demonstrated that he was a dead shot firing from the hip, without taking the time to aim his gun from the eye, which is something that we never attempted to teach in any activity in the Navy that I've been familiar with.

I have covered a little background here to lead to some of the more important things that we learned in Navy training.

We learned that effective organization of key training personnel and intelligent selection of key personnel are essential to good training results.

We learned that training is usually successful if good audio-visual training aids and synthetic training methods are intelligently used.

We learned that classroom training is deadly, and in some cases a waste of time, at least when you're dealing with the large numbers of men that we were dealing with.

We learned that student participation is essential; that you can't tell a man how to do something and then expect him to do it. You must show him how to do it and then let him do it, and then he learns.

We learned that effective methods must be employed for carrying the original enthusiasm, knowledge and ideas of the man who conceived the instruction, directly from him to the man who is being instructed, without permitting it to be detracted from

by passing through the hands of too many other people before it gets to the trainee.

We learned that effective training must be conducted under conditions simulating as closely as possible the conditions that the trainee will be faced with in the field when he is putting his training into effect.

And we learned that essential phases of training can't be neglected simply because the required equipment is hard to get or because the subject is hard to teach. There has been a great tendency to fall into these two traps in Navy training.

For example, one of the most important functions of an enlisted man in the Navy is that he should become an expert Sound-Powered-Telephone talker. The Sound-Powered-Telephone system embraces a tremendous milage of wires running throughout every Man-of-War. It's intended to be the communications system that you can fall back on after everything else is shot out, for the reason that these wires are run in so many various parts of the ship with circults duplicating themselves on different leads that you couldn't reasonably expect all circuits to be shot out at the same time. Another advantage is that the Sound-Powered-Telephone requires no source of electrical power other than the speaker's voice. It is exactly what it's name implies— the electrical power is generated by the vibrations of the talker's voice.

You can imagine the problems in dialect, enunciation and accuracy that we ran into in taking boys out of the mountains and off the farm, and trying to train them to be good Sound-Powered-Telephone talkers. The greatest problem of all was that if the meaning of a message were changed in the slightest degree, the chances were that is would have a very serious and perhaps a disastrous result.

I would like to give you one example of this. A ship was coming in to a pier and the Sound-Powered-Telephone talker on the bridge was hooked up with the Sound-Powered-Telephone talker on the forecastle deck, from which the forward mooring lines were handled. The Captain on the bridge passed a message down to the First Lieutenant on the forecastle deck through his Sound-Powered-Telephone talker and the order that he gave was "Avast Heaving" which simply means, you might say, "Stop Heaving"; but by the time the message got to the First Lieutenant from the talker on the forecastle deck, the message he received was "Are you bastards heaving?"

Part of our function out at Great Lakes was to train these men to be excellent Sound-Powered-Telephone talkers. However, ers Sound-Powered-Telephones just weren't available for training purposes. The fleet had them all. Furthermore, it was a most difficult art to teach. When I arrived there, I found that the instructors were giving lengthy lectures on Sound-Powered-Telephone Talking, with a few other devices, the net result of which was that when a man reported on board ship he had to be completely re-trained from the beginning in this art.

It caused me a great deal of grief at sea. On one ship particularly, I had a large number of telephone talkers under my supervision. We had to start in right at the beginning and try to teach them to be Sound-Powered-Telephone taikers under forward conditions.

So when I arrived at Great Lakes it seemed that quite a revision in the Sound-Powered-Telephone Talking was indicated.

The first thing we did was to try to simulate battle conditions. We proposed to start this class off, and a large number of other classes too, by calling the men to "General Quarters".

After sounding "General quarters", we proposed to have the men sit in bleachers just the way they'd be at a football game, and have them pass messages from one end of the benches to the other, repeating exactly what they heard from each preceeding man. It was discouraging to find how completely the meaning of the message would be changed by the time it went from one end of a bench to the other, but in a comparatively short period of this kind of drill, the men became excellent telephone talkers.

In order to make them more than good, after a short period of this kind of drill, we played recorded battle noises in the classroom while the messages were being repeated. This was all done entirely without the use of the Sound-Powered-Telephone. The instructor gave a short lecture on the telephone itself at sometime during this training, using one set of telephones to illustrate his lecture.

On board ship we had gone further and where the equipment was available, recorded the voices of the telephone talkers, for individual analysis of dialect and enunciation. Up to the time that I left Great Lakes we had not inaugurated this phase of the training there simply because we didn't have any wire recorders. The few the Navy had were with the fleet.

In using the Armour magnetic wire recorder for training merely by speaking into the microphone and then it's possible to play it bac kimmediately after rewinding, without the necessity of ing, without the necessary of waiting for any processing, I might say also that any part of the transcription can be immediately and easily erased, or you can simply record a correction directly over the portion of the transcription that you wish to change. The wire passes through the erase unit just a split second before the new recording is placed on the wire.

We learned in our Navy training that essential training cannot be neglected simply because the required equipment is hard to get or because the subject is hard to teach; that student participation is essential, and that classroom tarining is somewhat deadly and largely a waste of time unless the classroom training is adapted to student participation and unless good audio-visual training aids synthetic training methods are intelligently used to expedite and enhance results.

Want to emphasize here also the importance of conducting the training under identically the same conditions that the trainee will meet when he goes into the fleld to put his training into effect,

An outstanding example of this I think is our Fire Fighting Training, For a long time, we conducted the Fire Fighting Training under ideal conditions. The men were given complete and effective equipment in good condition and everything was done so that is would be certain they would have no difficulty in putting out the large fires we

built in steel replicas of destroyers holds and replicas of hangar decks of aircraft carriers.

As a matter of interest, one of the rigs in which we built fires was a large metal tank that contained a maze of pipes filled with gasoline under pressure. Many of the pipes had leaks in them and the gasoline squirted all over the place. We called it a 'Christmas Tree Fire' because when we touched it off with the torch, flames leaped out in every direction.

However, all of these fires were easy to put out under the early methods that we used, so we conceived the idea of trying to duplicate conditions that would be met on board ship in putting out large fires after the ship had been bombed or shot up in much the same way as the 'Bunker Hill' and the 'Franklin' and others that you've read about.

Incidentally, you'd be surprised at the large number of normal fires there are on a large Man-of-War, whether you're in combat or not. It's almost like the routine activity of a City Fire Department and frequently you get the Fire Alarm several times on normal routine days. But after you've heard this call a few times, you don't pay much attention to it unless you happen to have a particular fire station, in which case you're in much the same position as the firemen in a City Fire Department.

Well, after starting the Fire Fighting Class off by sounding "Fire Quarters" on the Public Address system at the Fire Fighting School, the men ran to their stations and instead of finding their hoses all neatly coiled up and in the proper place and in good working order, they'd find some of the hoses all shot up just as they would be after the ship had been shot up by suicide planes. Finally they would get a good hose run to the fire and find that there was no water pressure so that they would have to rig auxiliary pumping equipment; or one thing or another to give them the same conditions that they would be sure to find on board a ship that had been badly shot up. We proposed to create a number of situations of this kind which would give the men in training identically the same conditions that they would have to meet under combat conditions.

In this way, we not only eliminated the fear of fire from their minds but we also eliminated confusion from their minds by training them to expect unusual and difficult situations.

Now I'd like to go back to the first point that I made when I spoke of the most important things that we learned in Navy training, and that is my point that effective organization and intelligent selection of key personnel are essential.

On board ship our training organizations were rather simple. The training officer of the ship usually was the Executive Officer or the Navigator. Then an Assistant Training Officer was chosen who usually was some kind of a specialist in personnel work or training work. Under the supervision of these two officers, the Division Officers in the various departments of the ship were expected to conduct the training. They comprised the several Division Officers in each of several departments: the Gunnery Department, Navigation Department, Medical, Engineering, Hull and Damage Control, Supply Department and the Communications Department. If it were an aircraft carrier or any type of ship carrying aircraft, such as a cruiser, battleship or seaplane tender, you'd also have the air department. The great difficulty here lay in the fact that these people were chosen to conduct the training, with the exception of the assistant training officer, simply on the basis of the particular jobs that they happened to hold on the ship and not on the basis that they were in any sense qualified to carry on training work.

However, at Great Lakes we were a little more specialized and we were able to a certain extent to place the key personnel on the basis of their ability to do their jobs. I'd like to give you a short picture of the rather complicated organizational setup we had at Great Lakes.

Under the Commanding Officer and the Executive Officer came a series of departments which were concerned primarily with the normal activities that go on at any shore based Naval Station. We had the Personnel Department, Material or Supply Department and departments for the bands and athletics. Discipline was a big problem and we had a department to handle it. Then we had Insurance and Family Allowances—you'd be amazed at the number of millions of dollars of government insurance that was written at this command for 50,000 men; and then we had the Physical Training and Recreation Department. All of these activities, of course, were in addition to our regular training activities.

I might say as a matter of interest that we weren't required to conduct the feeding and housing and clothing of these men as there were separate commands that carried out those functions. However, it was necessary for us to supervise what was done in this respect and make certain that our men were properly fed, properly clothed and properly sheltered, so there was a great deal to be done before we even started to get into the training.

But for the training, we had our activities set up in the following manner:

Heading the whole business under our direct supervision was what we called the Planning and Training Officer. He was responsible for the training in from 9 to 13 regiments. Each regiment was made up of somewhere between 3,500 to 5,000 men.

The organizational setup within each regiment started at the top with a Regimental Commander, and under him a Regimental Training Officer; then there were 4 or 5 Battalion Commanders in each Regiment who were responsible both for Administration of their men and Training of their men. Under them, there were from 30 to 40 Company Commanders in each regiment, who had the direct contact with the Trainees.

Now to carry out these training activities we had a number of departments, serving all of the regiments: the Chemical Warfare Department, the Audio-Visual Department (which conceived and built many, if not most of the training aids that we used. I would say that this probably was the most important single activity that we had.) Then we had the Fire Fighter School; the Ordnance Department, which included both the indoor and outdoor rifle ranges, and the Boat House. And then we had a separate department set up for training in the Recognition of Aircraft and Surface Craft. Under all of these departments

(Continued on page 47)

Iron Ore

Sources & Prospects

Prepared by

CHARLES A. SCARLOTT

The following article reprinted from the Westinghouse Engineer is a continuation of material begun in the October issue. In that issue Mr. Scarlott discussed the resources of the Lake Superior region. In this section he concludes the survey.

Next in importance to the Lake Superior district as producers of iron ore ar ethe mines in the Birmingham region, and those of the northeastern district, which comprises New York, Pennsylvania and New Jersey. Normally the mines in Alabama account for 8 to 12 percent of the national total; the northeastern region, about four percent. All the other mines in the United States have accounted for less than two percent of the annual total.

The city of Birmingham, Alabama, is built on top of an underground body of ironbearing rock which, in tonnage, is enormous. It is poor in quality as compared to Lake Superior ore. A total reserve of one and a half to two billion tons (including the high-silica ore) is believed to remain in the Birmingham district. The Birmingham mines have a long time to go although they also have the problem of beneficiation to remove silica from the ores, in order to use much of the known reserve.

The Birmingham deposit illustrates beautifully the fact that something more than iron content is required for a deposit to be counted as ore. If located in the Lake Superior district, Alabama ores probably would not be classed as present workable ores, as the iron content is too low—only about 36 percent. But, unlike Lake Superior ores, a substantial part of these ores contain a large proportion of highly important lime (about 15.6 percent), which makes the ores to an appreciable extent self-fluxing.

The Birmingham ores are underground, although initially they were mined in open cuts along the outcrop. The Red Mountain ores occur in several sedimentary beds of which two have been important sources; the larger bed or seam varying from 15 to 30 feet thick, and the smaller from 4 to 6 feet. About 7 to 12 feet of the larger bed have been good enough to mine. These ores occur along a belt of outcrop that extends over 20 miles running generaly northeast and southwest, and tilted eastward at angles of 15 degrees to 30 degrees. Similar ore outcrops in thin seams continue far to the northeast, across Tennessee and beyond.

Nature was generous to the Birmingham region. Although she could have provided an iron ore of higher grade and more accessible, she did place beside it vast coal beds. The coal, too, is inferior in quality to the Pittsburgh seam, but it and the iron ore make up their quality deficiencies by their physical intimacy. On this fact rests the iron industry of Birmingham, which in prewar years produced about one twelfth of the pig iron in the United States.

Iron was taken from New York and Pennsylvania mines as early as 1710. These mines are still going strong. Although they have long been surpassed by the mines of the Lake region, they have continued year in and year out to contribute from 2.5 to 4.5 percent of the total. The ores, mainly underground, are of good quality, mostly magnetite, which can be magnetically concentrated to provide a very high-grade charge for the furnaces. Those mined in New York and New Jersey range from 30 to 50 percent iron, and the Cornwall ores, near Lebanon, Pennsylvania, nearly 45 percent iron. Most of these ores are easily concentrated to about 60 percent iron. They move mostly to furnaces in eastern Pennsylvania and New York, and also to the Buffalo and Pittsburgh districts, where they supplement the lake ore supply at some of these plants.

Great as is the concentration of the steel-making business in the North and East and in the Birmingham district, other producers about the country, although small by comparison, play increasingly important roles in our industrial economy and clearly must have sources of iron ore not too distant. Witness the blast furnace plants in Colorado, Utah, California and Texas, all supplying iron to steel plants in those areas. Many states have deposits of iron-bearing rock, but few have achieved commercial importance because of low grade, difficult mining, inadequate size, remoteness from other raw materials, or from markets. Forty-two sates have, at one time or another, produced iron ore.

Aside from the Birmingham district the southern states have probably several hundred million tons of hematite, limonite and carbonate ores, which are not likely to be considered workable for a long time to come. Limonite deposits scattered over northeastern Texas have been variously estimated up to 200 million tons. A new blast furnace at Houston and another at Daingerfield, Texas have been constructed during the war to use local ores, but the Daingerfield furnace has never operated. Colorado and New Mexico have small iron ore deposits of fifteen million tons or less, total. Eastern Wyoming—which supplies the Pueblo, Colorado, furnaces, has substantial reserves probably adequate for the plant for a long time. Reserves of all grades in Utah are estimated at upwards of 40 to 50 million tons available to the three blast furnaces at the new steel plant at Geneva, Utah, and to the two older furnaces at Provo. Some Utah ore moves also to Pueblo and some will be shipped to the new Kaiser furnace at Fontana—near Los Angeles, California. The Kaiser plant has been supplied heretofore with ore from a mine near Kelso, California. Arizona, Nevada, Oregon, Washington, and California have scattered small deposits. Under the pressure of war the output of

the western mines has increased. In 1942 they produced 1.48 million tons; in 1943, 2.45 million tons, and last year 2.8 million tons (of which Utah supplied 1.5 million tons). Percentage-wise, the increase has been from less than one percent to nearly three percent of the U. S. total.

Foreign ores have never been a large factor of competition to U.S. ores, but might be some time. There are several sources of such ore, some whopping big ones. The blast furnaces at Sparrows Point, Maryland, were built primarily to feed on Chilean ore, of which about 1½ million tons was imported annually. This, incidentally, comprised more than half of the total U. S. iron imports.

Chile has important deposits, mainly of hematite, about 60 percent natural iron. But the Chilean deposits are relatively small compared to those in Brazil, in the vicinity of Itabira and the highlands about 350 miles from the Atlantic coast. Inadequate transportation is a principal obstacle to these ores. The Itabira deposits are thought to contain several billion tons of hard hematite ore that is low in phosphorus. They average about 65 percent natural iron. They can be surface-mined or quarried the year around. The amount of overburden is small. Other important but less extensive deposits occur in Brazil southwest of Itabira—at Bello Horizonte—which are being developed to supply the new Brazilian steel plant at Volta Redonda. Venezuela has important deposits of high-grade iron ore, which are now being developed for use on our eastern seaboard.

Cuba's iron deposits are extensive, being estimated at over three billion tons, largely of earthy brown ore high in alumina and moisture (both combined and absorbed water), and containing appreciable proportions of chromium and nickel. After drying, these ores run about 46 percent iron. They are low in phosphorus. Other important sources and possible amounts in the western hemisphere include: Newfoundland, four billion tons; and Canada, at least 100 million tons of ore that can be produced competitively and a great deal more not workable according to present standards. The famed Steep Rock Isle deposit recently opened in Canada, just above the Minnesota border (where a lake was drained to give access to an iron-ore body), is more spectacular than significant in the world's totals. The tonnage of ore, running high in iron and low in silica and phosphorus, is now estimated to be of the order of 50 million tons.

Widespread iron-ore deposits in Northwest Labrador have been under exploration in the past few years. They are remote from transportation, in an area of rigorous climate, but these are not insuperable obstacles to their development.

Various foreign ores, mainly those in South America, are potential competitors to our mines in the United States. The extent of the competition depends on the various economic factors at home and abroad, and upon public policies affecting trade, and construction of the St. Lawrence river waterway.

That the United States cannot allow itself to be dependent on foreign sources of raw materials has been a recent painful lesson. The need for new or better methods of beneficiating low-grade iron ore is a national must. The need is here now and the urgency increases daily. We cannot wait until the good ore is gone before developing applicable methods. The need for low-cost beneficiation methods is sharply accentuated by the fact that the shortage of commercial grade ore reserves is so much more imminent for some producers than for others. A few companies, mostly the largest ones, have reserves ample perhaps for two or three decades, but the supplies available to other important, but smaller, companies are woefully short right now.

Fortunately the industry is not idle. Large sums have been spent and are being spent on beneficiation research. Twelve producers have for some time been supporting an extensive research program at Battelle Institute at Columbus, Ohio. The U. S. Bureau of Mines, the Mines Experiment Station at the University of Minnesota, and other public agencies have been hard at work on the problem for some years.

There is no single preferred method of beneficiation, not even for a single body of ore. For most, some relatively simple mechanical separation of the iron-bearing particles from the silica or sand grains, by washing, is adequate. By far most of the beneficiation now practiced in the Lake Superior District (all in Minnesota) is by such washing. Other methods make use also of the differences in relative densities of iron minerals and waste material and include crushing and grinding followed by heavy-medium separation or by jigging and hydraulic separation. Flotation methods, applicable to finely pulverized material, by which either the desirable or the undesirable components are floated off by use of chemical reagents are generally more expensive, and are not as yet applicable.

Magnetite ores can be concentrated by crushing and magnetic separation of the iron oxide from the silica. Hematite can be converted to magnetite for concentration by roasting. Much experimentation has been done in this direction, and one commercial plant is operated on the Cuyema Range, but the process is not yet considered generally competitive. Absence of low-cost fuel in the Lake Superior district hampers the roasting process there.

There is likely to be more extensive application of heavy-medium separation, sometimes called the "sink and float" process, such as is now practiced at several plants in Minnesota. The roughly crushed ore is fed into a cone in which is maintained a liquid consisting of a finely powdered ferro-silicon alloy and water, and the resulting mixture agitated. The density of the ferro-silicon liquid is intermediate to that of the iron ore and the silica, so that the silica rises to the top of the cone and overflows while the iron ore is drawn off below. The ferro-silicon is recovered for reuse magnetically.

The enormous taconite reserves in Minnesota are bound to be important in the long-range picture. This iron-bearing rock is hard, low in iron and high in silica. Concentration is difficult, but the research on the problem is expected to develop processes adequate to the requirements when needed. The magnetic taconite is amenable, of course, to well known methods of magnetic separation, but the fine-grained concentrate must be sintered or otherwise prepared for furnace use.

As the need for beneficiation increases, as its techniques improve, more and more will it

(Continued on page 56)

Industrial Research

The Pattern of the United States

by

HAROLD VAGTBORG

Research—possibly not as such in name—began with man. The tempo was extremely slow in the early days with only an occasional beat to mark a new discovery as the thousands of years rolled by First came fire and then the discoveries of what fire could do to the simpler materials. The beats came at long intervals, suddenly and unknowingly, because discoveries were generally accidental. Early man learned how to remove iron copper from ore with heat. He began to identify more and more of the materials of the earth and his ability to reveal the secrets of nature increased. Research began to take a more definite form. Many discoveries were kept secret and passed on from father to son. Others tried to imitate but often something was missing. These early beginnings led to the age of artisanship and craftsmanship. But the research tempo quickened and science marched on. The period of "cut and try" opened and man began to look for new secrets of nature rather than just to stumble onto them. Colt whittled the first revolver out of a piece of wood while he was whiling away the long hours on a sea journey. Fulton's first steamboat model was made in much the same way. At the same time, in many shops and laboratories, workers were mixing ingredients unceasingly hoping that each time the desired result would occur. Very often something would happen that was entirely different from what was expected and a discovery of great importance would be added to our knowledge of science.

Today the research approach is more basically sound. A problem is carefully analyzed and then segregated into its component parts for study. As missing links are supplied a complex picture becomes clear and a new discovery is added to our store of knowledge. This procedure has greatly increased the research tempo and its productiveness in accelerating. Today the world is research conscious and an activity which began in the laboratories of our educational institutions in a small way many years ago has become the pilot of industry. Many prefer to think of research as an industry in itself—one employing almost 70,000 workers in 2,350 research laboratories in 1940 at an approximate expense of $345,000,000.

But what of the research incentive? It certainly must exist to demand such attention and must take a variety of forms to engage a host of miscellaneous types of workers in both educational institutions and in industry. The incentives are many, of course, but the more obvious will include the following:

(1) **Success of past developments.** The over-all success of research activities during the past 50 years is a great stimulation to probe further the mysteries of nature.

(2) **Rapid growth in recent years of new industries.** Radio, television, the airplane, plastics, synthetic rubber, the wire recorder and new electronic applications in general spur us on to find new discoveries of the same importance.

(3) **Appreciation of future possibilities by use of newly available scientific tools.** X-ray diffraction, electron microscopy, atom structure investigating equipment, ultra-speed photography and just a few of these. What will they produce in the way of new and amazing developments?

(4) **Research may hold the answer to the conservation of existing materials and certainly does for the development of new ones.** How can we prevent great annual lose due to oxidation of iron and steel structures? What can be done to enable us to get more than 10 per cent of the power effectiveness of gasoline?

(5) **Social aspects of research.** There are three frontiers of development of employment—land, population increase, and new industries through research. In previous years our prosperity was due in a large measure to the first two and it becomes increasingly important to create new industries through research if our prosperity is to continue.

(6) **Research is the lifeblood of our free competitive system.** Industry is dependent for its continued growth and success on its ability to produce new and better products at lower cost.

(7) **Research offers not only monetary reward but professional advancement and recognition.** Of these two it is believed that the research workers in our educational institutions put much greater stress on the latter than the former.

We have considered briefly the background of research—its development, the magnitude of its activities, its products and its incentives. In considering the system under which it operates we shall limit ourselves to research in the physical sciences.

In discussing the system under which research is carried on in this country it seems desirable to classify the research agencies and compare their objectives. The following classification is generally acceptable and provides for all research activities of any significance.

Individuals
Companies
Associations and Industry Cooperatives
Commercial Testing Laboratories
Research Institutes
Foundations and Councils
Professional Societies
Universities and Colleges
Federal Government

Individuals.—It is true that practically every research development or discovery is the product of individual effort. This classification, however, refers to the scientist working in a private laboratory operated by his own resources. We are all familiar with numerous examples of this

kind and it is probably safe to say that most of the significant early developments in transportation, communication and manufacturing processes came about in this manner.

These laboratories are contemporary with those of past decades and their workers are urged on by enthusiasm for their work and their desire to serve their fellowmen. Edison, Marconi, Fulton, Newton and Franklin are typical of these and many of our great industries are the outcome of their efforts. The same kind of men are at work today contributing much to our research progress but in general are associated with industrial organizations or educational institutions where they have found advantages in having co-workers and extensive facilities.

Companies.—In normal years and certainly in the war years (1940-45) by far the largest proportion of industrial research was done by company laboratories. The research expenditure of these grew eightfold from 29 million dollars in 1920 to 234 million dollars in 1940, the latter expenditure representing about two-thirds of total expenditures for scientific research in the United States in that year. A survey by the National Association of Manufacturers revealed that in 1940 one hundred eighty-one member companies spent a minimum of 2 per cent of sales income each year on industrial research. A recent survey of American industry indicates that generally speaking postwar research activities will be doubled as soon as personnel and facilities become available.

Taking a reasonably normal prewar year, it is noted that the steel and the automotive industries each spent about $10,000,000 in research in 1939 and in the same year the chemical industry alone spent $20,000,000, which is equivalent to $4.30 per $100 of income. Numerous individual companies expend over $1,000,000 per year and the fact that appropriations for research are increased indicates lucrative returns.

New corporation laboratory projects are being announced regularly. Very recent ones of magnitude are a twenty million dollar research plant for General Motors, Inc., and a six million dollar unit for General Electric Company. A substantial proportion of corporate research expenditures covers projects which are "farmed out" to colleges and universities and to research institutes. Many of these projects are of a long-term fundamental or special nature and are ideally suited to investigation in laboratories away from the numerous interruptions generally caused by pressing production problems in corporation laboratories.

Scientific research has opened new fields for the employment of thousands by the development of new products which have created new industries. Fifteen of the major industries of today have been developed since 1880 and it has been estimated that these have created, directly or indirectly, 15,000,000 new jobs. In other words, one out of every four persons gainfully employed today owes his job to an industry which grew out of a research development since 1880.

Someone might say, however, that scientific research has also crippled other industries and thereby reduced employment. A good example of the unsoundness of this argument is that when the horse and buggy industry was at its height in 1900 it gave employment to approximately 1,000,000 persons, whereas the automotive industry in 1939, which replaced it, employed over 6,000,000.

At any rate, the industries have found that scientific research is essential to the improvement of existing products and the development of new ones. Industry's big problem today is the securing of proper personnel and naturally it is concerned about the serious effect the war has had on the training of young scientists. American industry will contribute much to the inevitable solution of this problem.

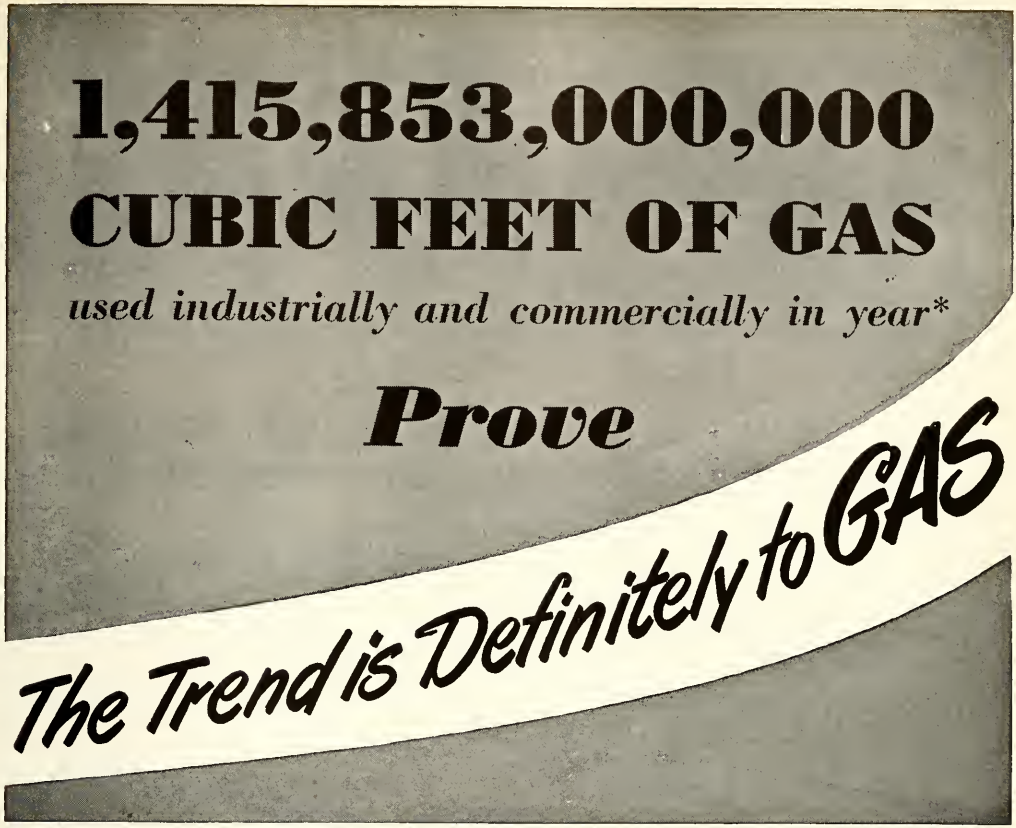
Associations and Industry Cooperatives.—A number of trade associations have actively participated in research through the years and follow the pattern of utilizing the laboratories of their associations, member companies or outside laboratories for the development of scientific information of value to their manufacturing operations. Ventilating fan manufacturers, for example, have conducted extensive investigations of standardization of capacities of their equipment on this basis. The Portland Cement Association conducts a great deal of research in advancing the quality and uses of Portland cement. The American Meat Institute as well as the American Petroleum Institute are organizations of an association nature operated to a large degree for the purpose of developing scientific information on the industry's products.

By industry cooperatives is meant a type of research organizations which has been developing particularly in recent years. The Institute of Paper Chemistry at Appleton, Wisconsin, initiated this move and was created for the purpose of not only conducting research of a basic nature on the problems of the paper and pulp industry, but also to train technologists for the industry. The training of men is considered as one of the most important features of the industry cooperative plan. In 1941 there was created by members of the gas industry the Institute of Gas Technology, affiliated with the Illinois Institute of Technology. This institute, as in the previously mentioned case, has an educational program paralleling a scientific research program for the gas industry. An institute of glass technology is in the process of development and the Textile Research Institute has been under way for a short time.

There are other organizations sponsored by industry on a rather broad basis but these are considered under the heading "Foundations and Councils" for the reason that their research projects are conducted as a rule outside of the organization.

Commercial Testing Laboratories.—It has been estimated that about 250 of these organizations are in operation in this country today. They are performing an important day by day service to industry primarily in the handling of physical tests and analyses requiring special facilities and personnel. A great number of the smaller industrial corporations not justified in maintaining their own testing laboratories have found such organizations most valuable. There are numerous instances where corporations of this kind have their routine analyses and testing problems handled by commercial testing

(Continued on page 56)



FOR over thirty years, the records show there has been an increasing trend to Gas for all industrial and commercial heat requirements. The last ten years have been most spectacular, use of Gas in these fields having doubled. The twelve months ending June 30, 1945 saw the staggering figure of ***one trillion, four hundred fifteen billion, eight hundred fifty-three million cubic feet of Gas*** consumed by industrial and business establishments.

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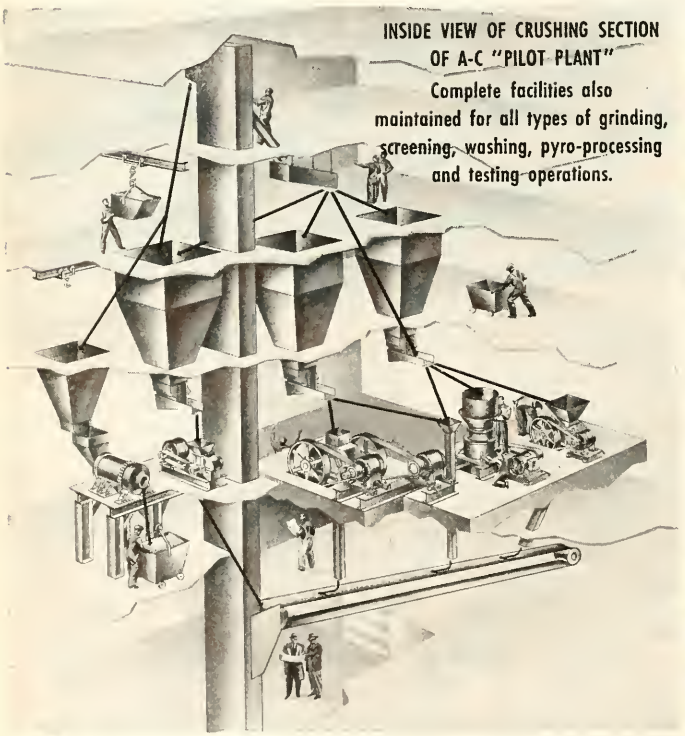
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420 Lexington Avenue, New York 17, N. Y.

For 12 months ending June 30, 1945. Figures do not include Natural Gas sold for generation of electricity.

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FOR ALL INDUSTRIAL HEATING

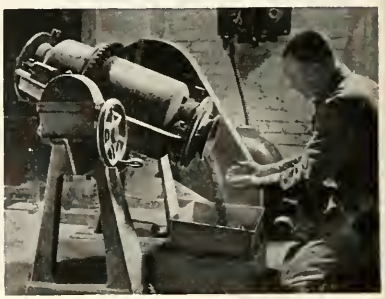
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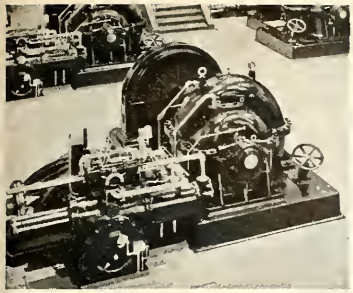
1 "How can we make more accurate equipment recommendations to meet specific process problems?" was the question A-C asked its own engineers. Their answer: build a laboratory so complete in every detail that it can simulate actual mill conditions no matter what the locality or basic material involved. Today, that laboratory is ready for use at A-C (crushing section above)—*one of the most extensive ever built to serve the basic industries!*



2 Inside this "pilot plant," sample ores, non-metallic minerals and synthetics can be "batch-tested" by the pound or bulk-processed in ton or carload lots. Processors and their engineers can select the right equipment to suit specific needs!



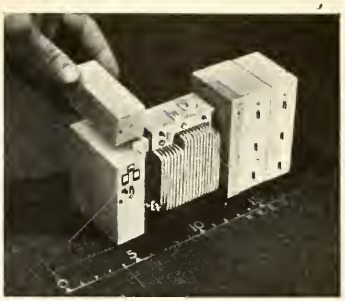
3 From the smallest vibrating screen to the largest kiln (above), Allis-Chalmers builds the most complete line of processing and milling equipment in the world! We're ready to help you with your technical problems.



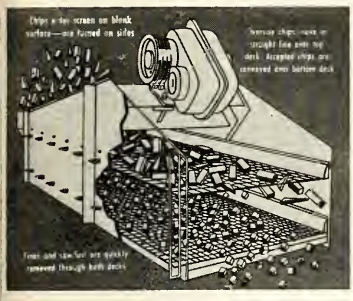
4 Look, for instance, what A-C engineering has done in water distribution. Today, one A-C Centrifugal Pump does the job of 3 old-type pumping engines 10 times its size—*does it better . . . more economically!*



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The core of the tiny doughnut-shaped coil consists of a small ceramic form wound with permalloy tape 3/32nds of an inch wide and in thickness about 1/20th the diameter of a human hair. The problem was how to wind 1 50th of a gram of this fragile tape around each core, and then to wind fine wire around the taped form.

Western Electric engineers discovered that a standard coil winding machine could be adapted for wrapping the foil-like tape around the form. However, when it came to applying the required forty turns of wire, they found that the only effective method was to have the wire *sewn by hand* around the minute core through the hole in the center . . . in much the same way that a seamstress sews around a buttonhole!

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SOURCE OF SUPPLY FOR THE BELL TELEPHONE SYSTEM

Alice and the Slide Rule

(Continued from page 20)

sors of theoretical mechanics, who teach them in the next hour, use slugs."

"How does a girl computor like you come to know so much physics-" said the Mad Hatter.

"Well," said Alice, "the talk about slugs and gee-pounds and three different kinds of weight and poundals and kilogram-force and dynes and pressure in bars, was a Wonderland more mixed up than anything the other Alice ever got into, so I studied and found the only way out was to keep on with the good old-fashioned pound-mass."

"Well," said the Mad Hatter, "even if everybody once used the pound-mass and every day people still use it, lots of people have learned slugs and have come to believe them best, and we have to please them."

"We must re-educate them," said Alice. "Lots of people once believed in caloric and the luminiferous ether and phlogiston and said 'force' where we now say 'energy', and they re-educated themselves. Mass measured in slugs or as W/g is not essentially wrong like those things, but it has been part of many people's education. So the sluggers must realize that slugs do cause confusion, and that there is a point of view that uses the pound-mass as it is used in every day life, and that many engineers use it with complete accuracy, with the 32.1740 in Newton's second Law as a proportionality constant without dimensions. Then the sluggers may be willing to be re-educated.

"Anyway," continued Alice Jr., "no slugger is going to befuddle me the way they do lots of college students with their slimy old slugs. I am willing to give up the word 'weight' and use the word 'mass' instead, but it's got to be the pound-mass. So nuts to your slugs."

The Mad Hatter didn't seem convinced, but he was so vexed that he had no answer and disappeared. Thoughts of slide rules and notebooks returned to Alice. But she was too confused and sleepy to do more work that night, so she was soon in bed, and, with the soporific melody of the Mock Turtle's song running through her head, fell fast asleep.

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Carbon Black

(Continued from page 12)

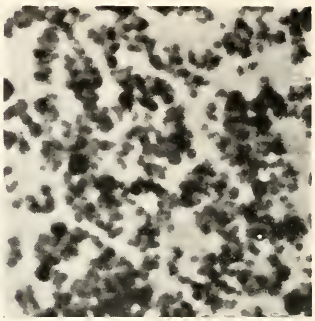


Fig. 5. Electron micrograph of Continex SRF, a semireinforcing furnace black (SRF), at 50,000 diameters magnification.

photographs of an MPC channel and an SRF furnace black are shown in Figures 5 and 6. It was originally thought that the particles are separate spheroids and that the agglomerates were superimposed particles or clumps resulting from imperfect dispersion. However, stereoscopic electron micrographs (106) now indicate that the particles may actually be fused together. This result may help to explain the comparatively high modulus of carbon black loaded rubber as pointed out later. However, the concept of firmly attached clusters does not appear to be in harmony with the experiments of Parkinson (62). Parkinson determined the

(Continued on page 40)

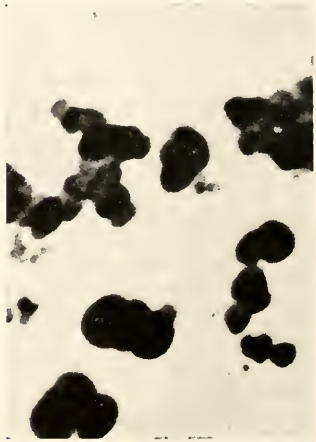
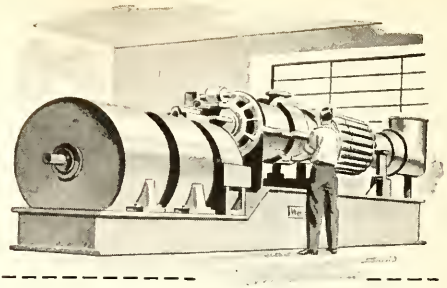
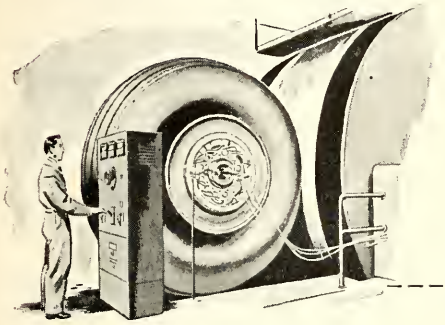


Fig. 6. Electron micrograph of Continental A, a medium processing channel black (MPC) at 50,000 diameters magnification

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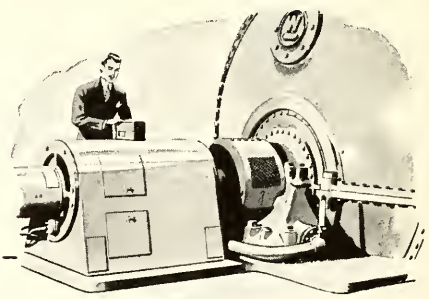
On a special machine a TESTER employs a Rototrol* for smoothly accelerating a large flywheel, used in determining the wear-resisting qualities of tires and brakes—for huge air transports of the future.

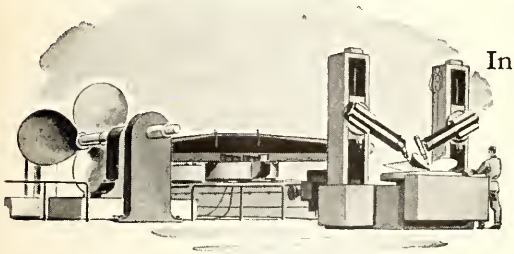
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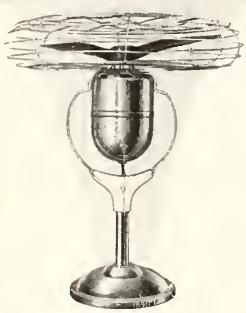
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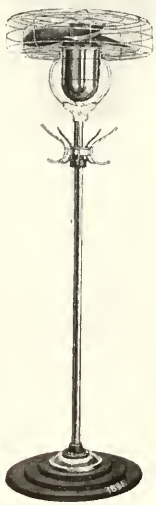
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Our Future Engineers

(Continued from page 18)

in one of your New Orleans papers expresses some very sound ideas in regard to the release of information about the atomic bomb. "Since the world has been drenched with all sorts of conflicting misinformation about the bomb from seers and commentators, most of whom can't know anything whatever about it themselves, and almost none of us are able to check their authorities, we should like to see the President put an end to the public befuddlement and confusion resulting. He could do this by plainly identifying the very few chemists, physicists and engineers who really organized, co-ordinated and directed the work on it, who therefore know most about it at every angle.

"These men might then inform and advise everybody whenever important questions arise. Really informed public opinion is highly desirable in every case, but never so essential to the best results as in a matter so titanic in its bearing on human welfare as the atomic bomb."

This has been quoted as it could not be expressed any better or with any sounder logic.

Congress, at the present time, is crowded with bills seeking to do something for the benefit of the scientists, the technologists and the engineers, or bills which will make it more difficult and hazardous for these individuals to practice their profession in the future. We should be informed in regard to these bills and, as scientists, technologists and engineers, should express our opinions as to their advisability or inadvisability. Some of these bills are on such material as follows:

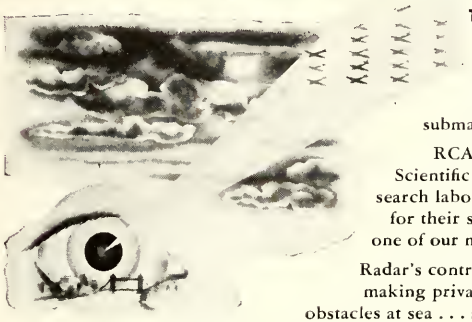
1. Government sponsored and controlled research.
2. Placing all research and research laboratories together, with personnel, facilities, data and patents ensuing, under the control of a governmental appointed board.
3. Bills galore stating how we should treat our knowledge of the atomic bomb.
4. Legislation on taxation which recognizes the propriety of deducting from income, expenses incurred for research.
5. In many states, not now having legislation regarding the licensing of professional engineers, there is agitation seeking to secure the passage of such legislation.

It seems to the speaker, therefore, that our engineering organizations of all kinds have, at the present moment, ample subjects for discussion transcending the customary presentation of papers purporting to be of a scientific nature.

In all of the millions and millions of printed and spoken words employed by the press and radio in acquainting America with the discovery of the ways and means of utilizing atomic energy, we believe none were employed to suggest that scientists be given a direct role in the shaping of the world that is to be. Praise, to be sure, was heaped upon those who pioneered in their roles as scientists, yet few venture the opinion that scientists be invited to participate in the control of the use of atomic energy. Why?

Some will say that this refusal comes from a lack of sufficient publicity for the men and women of science. But is this really so? Scientists receive tremendous amounts of publicity, but almost universally that publicity is solely based on outstanding scientific achievements. When the men and women of science come out of their laboratories and in large numbers actively participate in the affairs of the world, when they contribute to the shaping of social, cultural, governmental, and international policies in common with other professions and groups and with the same force and conviction, then they will be publicized, not only for their scientific achievements, but also for their roles as molders of public opinion. Until we as individuals and in large numbers are willing to divide our time and energy between scientific pursuits and the affairs of government and of the world, we will continue to be largely ignored. We have a moral responsibility to mankind to assist it in so governing itself that the forces we release are reserved for good, not for evil. No one man, no small group can perform this service. It is the responsibility of every individual who rightfully calls himself a scientist and cannot delegate that personal responsibility to others.

RCA's role in RADAR



The story of Radar—the magic beam that enabled the United States Navy to sink a Jap battleship eight miles away at night . . . that helped save England in her darkest hours by detecting enemy planes . . . that automatically aims guns and detects submarines . . . this whole story is now officially released.

RCA takes this opportunity to congratulate the Office of Scientific Research and Development, the Army and Navy research laboratories and all other elements of the radio industry for their splendid work in so perfecting Radar that it became one of our most powerful weapons in winning the war.

Radar's contributions in peacetime will be equally as great . . . in making private and commercial flying even safer . . . in detecting obstacles at sea . . . and in hundreds of other ways yet to be discovered.

As for our part in this great effort, we here list the major developments in Radar made by RCA

1932—RCA Laboratories originated micro-wave equipment, which later was used in successful radar experiments.

1934—Echoes were obtained with micro-wave equipment set up near Sandy Hook. This experiment showed for the first time the potentialities of micro-wave radar.

1935—An experimental micro-wave pulse radar system was developed by RCA Laboratories. It was demonstrated to the Army and Navy in 1936.

1936—A lower frequency high power radar was supplied to the Army by RCA.

1937—RCA micro-wave radar was used to scan the Philadelphia skyline with cathode ray indication essentially the same used in today's newest radar sets.

1937—RCA developed an airborne pulse radar. This equipment operated very satisfactorily for detecting obstacles such as mountains, and was also invaluable as an altimeter. It was demonstrated to the Army and Navy in 1937, and at their request was classified as "secret."

1938—RCA started development of a practical altimeter employing FM principles. This and the RCA pulse altimeter later became standard equipment for the Army, Navy, and the British. A large quantity of altimeters of these types have been manufactured for controlling the height of paratroop planes at the time of jumping, for use in bombing enemy ships, and for other military purposes.

1938-9—RCA Victor manufactured the first radar equipment purchased by the Navy.

1939-40—Twenty high-power sets, based on the Navy's design, were developed and installed by RCA Victor in the Navy's important vessels.

1940—RCA developed and built radar apparatus which was especially suited for use on destroyers, and apparatus designed especially for submarines. These equipments were among the earliest procured by the Navy, and have proved very successful.

1940—Experience in the manufacture of vacuum tubes made it possible for RCA Victor to be the first and only manufacturer in the United States to produce a radar tube developed in England. RCA also produces many other types of radar tubes, including the cathode ray tubes of which RCA is largest manufacturer in the world. RCA's unchallenged leadership in cathode ray tubes for radar was made possible by extensive developments in television, since television, too, requires high quality cathode ray tubes.

1941—RCA Victor supplied receivers and indicators for the type of radar then used by the Army.

1942—Loran, a system of long-range navigation, was manufactured by several firms, but difficulties were encountered because of size and weight of the receiver. In 1942 RCA Laboratories undertook the design of a simplified, compact receiver, and achieved such success that large quantities were ordered from RCA Victor and from other firms instructed in RCA's design, and other types were discontinued.

• • •

Some of RCA developments are of major importance in developments of other concerns engaged in radar manufacture.

RCA gave complete design and instruction to other firms in altimeters, tail warning devices, bombing devices, tubes, Loran receivers and other radar equipment designed and developed by RCA.

Several hundred RCA specialists were abroad during the war servicing radar and communication services for Army and Navy equipment made by RCA and other firms.

RCA was represented on the National Defense Research Committee and on other government technical committees on war activities.

RCA engineers have been loaned to government laboratories for special radar projects.

RCA has co-operated with England in radar projects.

RCA

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(*Continued from page 36*)

average diameter of carbon black by ultra-centrifugal sedimentation and obtained good agreement with the average diameter measured by the electron microscope. If particles were present in even small agglomerates, sedimentation rate would be changed appreciably and the average diameter determined by this method would not be likely to agree with that obtained by measuring the diameter of the individual spheroidal particles appearing in electron micrographs.

In figures 5 and 6 the surface of the particles appears to be smooth. Definite evidence that the surfaces of most carbon black particles have no appreciable roughness was obtained when it was found that the total surface area determined by adsorption experiments was in good agreement with the area calculated from electron microscope photographs* (18, 19, 27, 40). Since the area measured by adsorption includes the surface on the walls of pores and crevices as well as the exterior surface, these results also show that the particles are non-porous or at least that pores large enough to admit a molecule of nitrogen do not exist.**

The apparent rounded structure of the particles is also supported by X-ray (7, 16, 23) and electron diffraction (99), measurements which show that the crystals present are much smaller than even the particles which appear on electron micrographs. Since an average particle contains several thousand tiny crystallites, we would expect to see not the sharp corners and flat faces characteristic of a single crystal but a smoothly rounded surface, the individual crystal edges being too small to distinguish. Actually straight edges and corners have only been reported in electron micrographs of carbon black in two instances and even then the particles were probably not representative of the bulk of the material (73, 106).

Surface Chemistry of the Carbon Particles

Although the surface of carbon black is smooth compared to the dimensions of the particle itself, it is not homogeneous from a chemical standpoint. That is, in addition to carbon atoms, the surface contains hydrogen and oxygen atoms (5, 51, 52). Moreover, the oxygen may be present in several types of surface complexes (10, 19). At least two types have been detected, an acidic complex having the empirical formula $(C_2O_3)_n$ and structures such as A or B in Figure 7 and a neutral complex $(CO)_m$ which may be represented by C or D in the figure.*

The adsorption of water occurs on both types of complexes and is dependent only on the total oxygen on the surface (21). Basic materials such as DPG (diphenylguanidine), are adsorbed from dilute solutions only on the $(C_2O_3)_n$ complex (19, 103). On the other hand, iodine appears to be adsorbed on the $(CO)_m$ covered surface but not on the $(C_2O_3)_n$ surface when the adsorption takes place from fairly low concentration potassium tri-iodide solutions.

Surface constituents also have an effect on the properties of rubber compounds loaded with carbon black. The retarding effect of the oxygen content of carbon blacks on vulcanization has long been recognized (6, 51, 101, 104). More recently it has been shown that rate of cure varies in a regular manner with surface oxygen contents ranging from zero up to a saturated surface and that other rubber properties such as modulus appear to decrease regularly with increasing surface oxygen (10, 77, 111).

The hydrogen content of the surface and the size of the crystallites composing the particles of a carbon black may also play an important role in rubber properties (10, 22, 78).

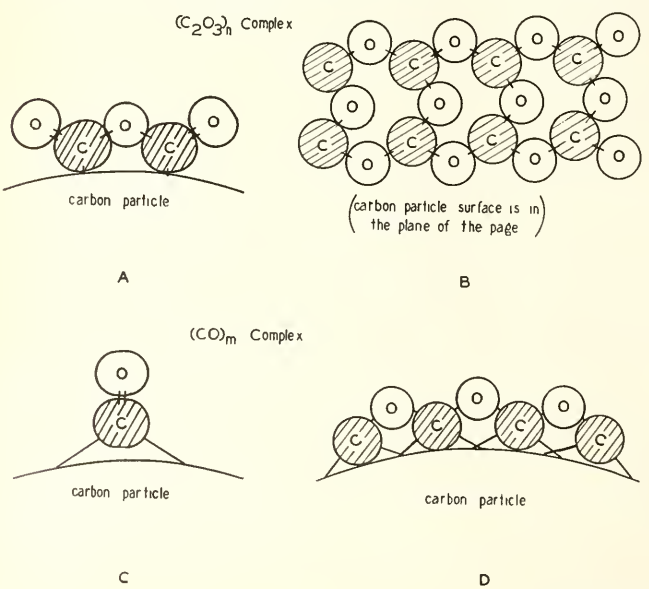
Reinforcement of Elastomers

The improved knowledge that we now have of the size, shape, and structure of the different carbon blacks and also of other pigments have made possible at least a first attempt at calculation of the actual stresses and strains set up in a rubber medium as a result of the presence of pigment particles. From an analysis of these stresses and strains the effect of a pigment on the properties of the rubber can be calculated. Thus in the last few years some progress has been made toward an explantation of the puzzling but vitally important reinforcing action exhibited by carbon blacks

*The recent data of Wiegand and Ladd (106) mentioned above would not be inconsistent with this result since the area of a group of spheroidal particles fused together at a few contact points would not be appreciably different than the area of the separate particles.

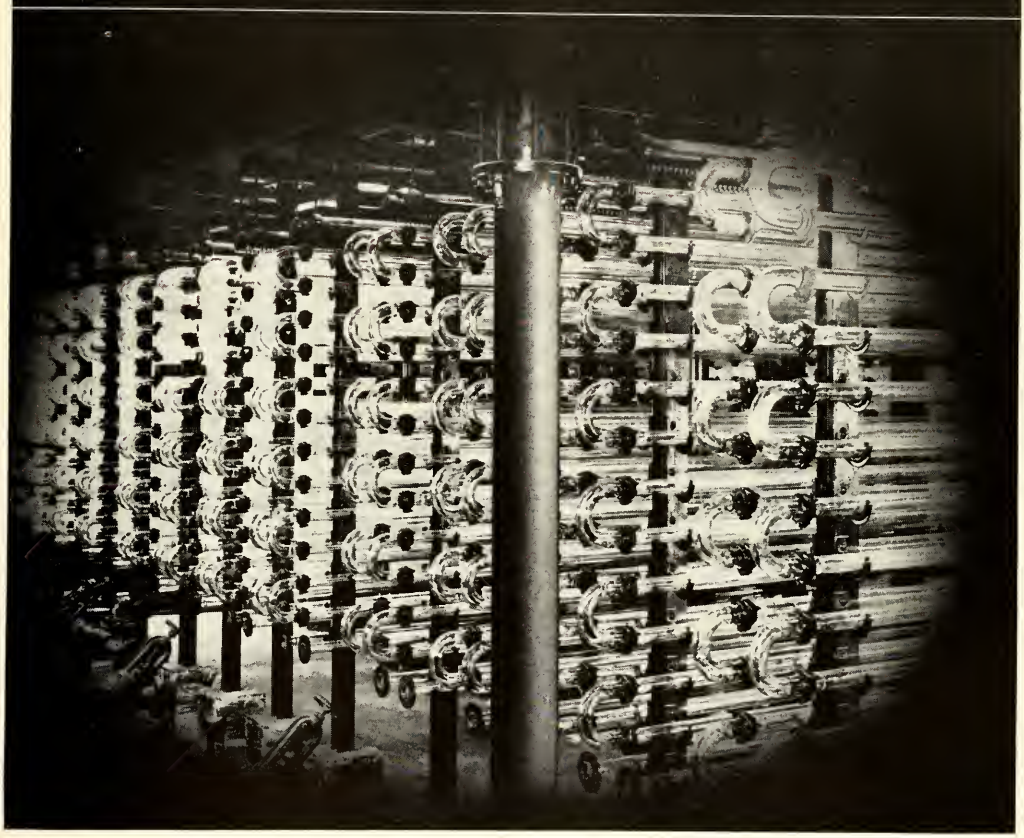
**Other results (71) indicate that pores sufficiently large to admit helium may be present in acetylene black but not in channel or furnace blacks.

Fig. 8. Possible configuration for oxide complexes on the surface of carbon black



*Various types of oxide complexes have also been reported on other carbon materials such as active carbon and coal (55, 69, 70, 72).

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and to a lesser degree by other pigments.

Reinforcement may be defined as the increase in service life of a tire tread or similar article resulting from the incorporation of a solid filler. Since a reasonably convenient, reproducible method of determining service life is usually not available, improvement in such properties as tensile, strength, modulus (stress at a given elongation), elongation at rupture, abrasion resistance, and tear resistance, are taken as measures of reinforcement. The reinforcing action produced by pigment addition is also accompanied by undesirable changes such as increase in hysteresis loss (decrease in resilience) and consequently an increase in heat developed on periodic flexing. In any actual article such as a tire tread, the amount and kind of reinforcing pigment must be properly selected to give maximum increase in desirable properties consonant with hysteresis low enough to prevent excessively high running temperature. Only in this way can maximum service life be realized.

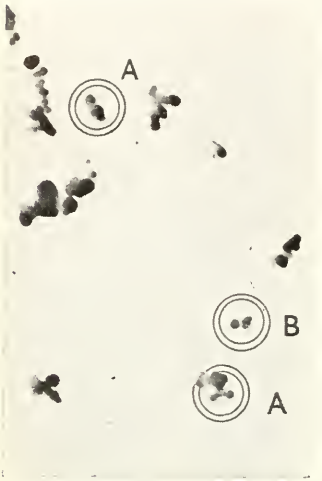


Fig. 8. Electron micrograph of Continex SRF showing particles which appear to be fused together rather than superimposed (A, A) and particles apparently connected by rods (B), at 20,000 diameters magnification.

Dependence of Modulus on Pigment Properties

Of the various properties involved in reinforcement only modulus has so far been subjected to theoretical analysis (46, 48, 67, 76, 98). Rigid particles imbedded in an elastic medium which adheres firmly to the particle surface, change the elastic constants (modulus, etc.) of the medium in the same way that similar



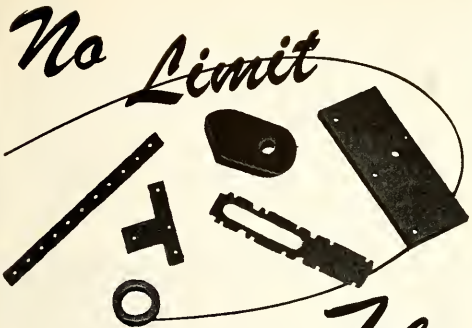
Fig. 9. Electron micrograph of Witco lampblack at 20,000 diameters magnification. The chains of fused particles are clearly visible.

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particles would change the viscosity of a fluid in which they were suspended. The percentage increase over the modulus of the unloaded elastomer depends on the following factors:

1. *The volume loading.* Modulus increases with loading.

2. *The shape of the particles.* Modulus is lower for a sphere than for filaments or platelets.

Carbon blacks such as high modulus furnace (HMF), acetylene black, and lampblack in which irregular agglomerates or chain-like aggregates persist even in rubber (Column 8, Table II), have higher modulus than blacks of similar particle size which exist chiefly as individual particles. The tendency to agglomerate has been called "structure" by Wiegand and co-workers (85, 90, 100). The author previously attributed this tendency to adsorption (Van der Waals) forces or electrical di-pole attraction which in turn were thought to be dependent on the crystal structure, that is, the size and degree of orderliness (graphitization) of the crystallites from which the individual carbon black particles are built up (18, 22, 23, 30, 66). The recent work of Wiegand and Ladd (106), mentioned previously, opens up another possibility: namely, that the agglomerates are rigidly attached to each other probably by carbon-carbon bonds. In support of Wiegand and Ladd's observations, Figure 8 shows an electron micrograph in which some of the encircled particles appear to be fused together while others are connected by rods. Figure 9 shows Witco Lampblack in which the chain structure is very pronounced, the filaments of fused carbon particles being easily recognizable. These results enable the high modulus of blacks such as HMF, acetylene, and lampblack to be explained from considerations of shape more simply than if only adsorption or di-pole forces held the agglomerates together.

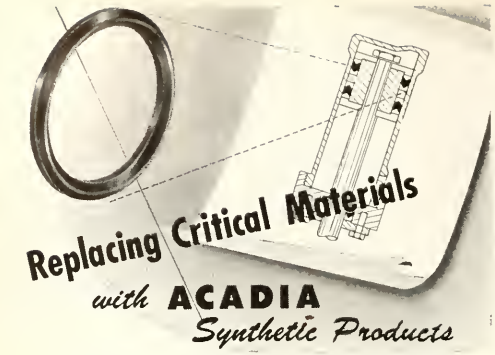
Clays, the particles of which are platelets have much higher modulus than symmetrical inorganic pigments such as calcium carbonates (108) again demonstrating the effect of particle shape.

3. *The extent to which the elastic medium is adsorbed and partially immobilized (elastic contents changed) by the pigment.* This depends on both the nature and extent of the surface of the pigment.

The effect of the nature of the surface is illustrated by the fact that carbon blacks which have an organophilic surface and might be expected to adsorb rubber to a high degree, have highier modulus than inorganic pigments (metal oxides and carbonates) of similar particle size and shape. Also channel blacks which have higher surface area than semi-reinforcing furnace blacks have slightly higher modulus at least in GR-S.*

Although much remains to be done before we have a complete explanation for reinforcement, at least a beginning has been made which is highly encouraging in view of the confused state of our

*The effect of particle size or surface area on modulus and other rubber properties has been discussed in numerous publications (10, 15, 18, 22, 23, 24, 25, 27, 30, 31, 32, 33, 38, 50, 59, 63, 66, 73, 77, 77, 85, 87, 88, 105, 108).



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knowledge up to only a few years ago.

Post War Prospects

The urge to try to see into the future is a human failing to which scientists have a particularly low resistance. The writer certainly not qualifying as one of those favored individuals immune to the virus, we will consider briefly the question of how much of the huge new carbon plant capacity will be required after the post-war replacement back-log is satisfied. Dr. Dinsmore, vice-president of Goodyear Tire & Rubber Co. has estimated that in 1948-9 when world rubber consumption will again have leveled off from post-war replacement needs, the world consumption of rubber will be about 1,500,000 long tons per year (3.4 billion pounds) (37). This compares to an average of 1,100,000 long tons between 1936 and 1940 (57). Assuming for the moment that this amount is equally divided between synthetic rubber and natural rubber, the carbon black requirements for rubber would be about 1.1 billion pounds.* At the present time more than 95% of the total carbon black consumed goes into rubber (60) so that the total demand for all purposes would be about 1.15 billion lbs. which compares to a world production capacity of not less than 1.5 billion lbs. per year.** The conclusion appears inescapable that if new large scale uses of carbon black are not found some of the less economical plants will have to be closed.

Besides the grades of carbon black listed in Table II, water dispersions of carbon black and a large number of non-rubber grades at present used only in small volume for paints, inks, paper, and various miscellaneous purposes are manufactured (10, 42). In these applications, carbon black is used either for color, improvement in physical properties such as tensile strength, or electrical conductivity. New and possibly promising uses for special grades are in the field of conducting coatings, conducting flooring and rug backing (to eliminate static electricity) (25, 53); in plastics as a reinforcing agent (10); in concrete road surfaces for reducing glare and for traffic markings (10, 109); and, perhaps, as absorbents, catalyst supporters, or catalysts. The extreme fineness of subdivision—among the finest of any commercial materials—the high purity, uniformity, and dispersibility of carbon blacks as well as their availability will recommend these materials for wider uses than they have hitherto enjoyed. It appears more than likely that an energetic search will reveal many new possibilities for these unique and interesting pigments.

The author wishes to express his thanks to I. Drogin, United Carbon Company, for his permission to use Figures 2, 3, and 4; to J. J. Tolpin, Universal Oil Products, for his helpful suggestions; to P. L. Copeland, Illinois Institute of Technology, who took the electron microscope pictures, and to the various persons in the Witco and Continental Carbon organizations for their helpful comments and assistance.

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*On the average about 21 pounds of carbon per hundred pounds of natural rubber and 42 pounds of carbon black per hundred of synthetic rubber are required (57).

**1.45 billion in the United States (57) and at least 0.5 billion in other countries. Owing to recent cutbacks in the carbon plant construction program the figure for United States production may be somewhat high.



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The Five Year Gap

(Continued from page 21)

upper twenty five per cent of their class should attempt graduate study. Let us briefly consider some of these plans.

The Fellowship or Scholarship

If the employer contacts a returning sailor, soldier, or marine who, in the employer's opinion, is a man likely to succeed and become a valuable asset to the company, then every effort must be made to help that man succeed. One means of accomplishing this most rapidly, is to place the man on the payroll under contract, verbal or written. The amount of the fellowship or scholarship must give the soldier-student, so long as he does well in his studies, an income that will allow him to support his wife and child in decent comfort and to pursue his education without undue financial worries. This plan is best suited to the man who has from one to three semesters of study to reach either a bachelar's or master's degree. In fairness to the company that supports him, he should work for a specified number of years, usually from one to three, for that company after graduation. The student should also work for the company during vacation periods and thereby gain a bit in practical experience. Two thousand dollars can help to plug the "five-year gap" in a most effective manner. His rights under the "G. I. Bill" can be added to his income from the scholarship or fellowship.

Part Time Evening Study

The Veterans Administration recognizes part time programs for ex-service men. If he works thirty nine hours per week or less, he may elect to spread his allotted educational program over a longer span of years at a slower pace. Let us suppose that the veteran is entitled tofour semesters of academic study. Twelve hours or more is considered to be a full schedule and he receives (if he is married) the full seventy five dollars per month plus his tuition, fees and books for the four semesters. If he registers for nine hours of study he is eligible for three-fourths of these benefits. Three hours is considered a one-fourth schedule

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Training for Battle

(Continued from page 26)

were a large number of instructors who, again, had direct contact with the trainees.

Well now, you can readily see that any idea or piece of knowledge that originated with the Commanding Officer or the Executive Officer, had to go through all of these other people in all of these departments before it finally got down to the Trainee. No matter how much enthusiasm or knowledge or technical understanding of the problem at hand, may have been in the minds of the Commanding Officer or the Executive Officer or the Planning and Training Officer, by the time it got down to the Trainee a large percentage of it was lost.

We had to conceive methods for carrying the instruction directly from the man who conceived it to the man who was being instructed.

This was accomplished to a more or less satisfactory degree by the use of written material, some of which was for the use of the instructors and some of which was for study by the trainees. For the instructors, we had every lecture printed up in standardized form so that presumably all instructors would give the same lectures in identically the same way. It was complete in every detail. Then we supplied the instructors with printed books and pamphlets, giving them further information on the particular things that they were teaching. We also had meetings of the instructors.

For the men, we had the Blue Jacket's Manual which is supposed to be the sailor's complete and accurate authority on all problems that he is likely to meet during his Naval career.

The difficulty with these things was that neither the instructors nor the trainees paid a great deal of attention to them and actually they weren't very effective in our training.

At the time that I left Great Lakes, we were in the process of making plans to convey the instruction and ideas and enthusiasm of the people who conceived the training at the top directly to the trainees at the other end of the scale by the use of magnetic wire recorders.

The difficulty at that time was that wire recorders were just not available and I might say that they're still not available in any quantity, but that would have solved this serious problem for us if we'd been able to get enough wire recorders to do it effectively.

The limited number of wire recorders that we had in the Navy were used very extensively for training purposes. One of their greatest uses, of course, was in training for voice communication to analyze defects in enunciation and dialects as well as to analyze effective methods of communication procedures. They were also used extensively in flight training of pilots. The instructions given in the air by the instructor to the student would be recorded for two major purposes; first, to maintain a record of the instruction given by experienced, superior instructors to serve as models for newer and less experienced instructors; and secondly, to review and analyze the instruction methods used by any particular instructor, later, at his leisure, on the ground.

The wire recorder was also used extensively in training men in the detection of enemy submarines. It probably served a greater role in this phase of Navy training than in any other. Many actual attacks by destroyers and destroyer escorts against enemy submarines have been recorded and then used to train Sound Men at a later date.

So a large number of actual submarine attacks were recorded and the recordings were brought back and used in operational training schools so that the men could obtain first hand experience before they actually went to sea.

Before leaving the subject of the training methods we employed I must mention two other very important phases of Navy training. One is the Class A Service School which many enlisted men attended for periods of several weeks or months. These schools covered all of the technical fields for which rated men were trained, ranging through the rates of Machinist's Mate, Quartermaster, Torpedoman, and nearly all others including Ship's Cook and Steward's Mate, but with the exception of a few important fields such as Seamanship. There was no Service School for Coxwains or Boatswain's Mates.

A man who has completed a course in one of the Navy's Class A Service Schools has had a technical training comparable to that which he would receive at a good civilian trade school.

The other training procedure I want to mention which is very important, but which I will only mention in passing, is the series of Navy Training Courses which were used in training men for advancement in rating. The Navy Training Course is a complete, thorough, and accurate text book. It is entitled "Instructions for Use in Preparation for the Rating of Quartermaster 1C (First Class)," or any other rate that the particular course may cover. It deals in great detail with the technical subjects to which it relates. A book of this nature has been prepared for nearly every rate in every branch of the Naval Service. It is broken down into about twenty separate lessons for study, in much the same manner as a correspondence course. By his own volition and at his own convenience, the man studies one lesson and then takes an examination under the supervision of an officer on the subjects covered in that particular lesson. After he has completed one lesson, he goes on to the next until he has completed the entire course. Then, if he meets other required qualifications, he is advanced to the next higher rate in his branch of the service.

There are also many excellent correspondence courses available to officers. These are indulged in extensively in peace time, but only in rare cases have I known officers to complete any of these correspondence courses during the war, with the exception of the course in Navy Regulations, which was a required course.

I think now that I've covered the training methods that we used as extensively as it is possible to do in this talk. I'd like to discuss the subject of motivation both of the instructors and the trainees. It was very difficult for us to use effective methods of motivation because in the Armed Services there seems to be little reward for anything other than length of time served. We could not reward good instructors by advancement in rating or rank nor by increase in pay; but we did develop one scheme that seemed to work

pretty well. We created what we called the "Company Commander of the Month" and it was our intention to put a decorative panel right in the Commanding Officer's office which would display the photographs and names of the leading Company Commanders of the Month, choosing the best Company from each Regiment. The Company Commanders, knowing that their photographs would be displayed in the Commanding Officer's office for a period of a month if they did a winning job, probably would try a little bit harder and do their work a little bit better. While we didn't actually get this system into operation before I left the Lakes, I understand that it is being done now and that it is very effective.

For the trainees we had several competitions, chief of which was what we called the "Rooster Competition". This centered largely on judging men by companies in military drill. There were also similar competitions in cleanliness and general attitude as expressed by what they did in athletics and other activities. The winning "Rooster" company was awarded a red flag bearing a cutout of a white Rooster. Many of the companies that won these flags were so proud of them that they carried them with them wherever they went, to the classroom or the rifle ranges or any place that they marched in formation. If they had a Rooster Flag, you'd usually find it at the head of the company.

Then we also conceived what we called the "Incentive Plan". Again, this is something that was just being put into effect at the time that I left Great Lakes, and I'm not sure whether it's being used now or how effective it is, but we worked out a method for judging and rating every single man in the barracks along with the ratings of the other men in his company. We did test it before I left Great Lakes and the test was very effective. The men were most anxious that their rating should be near the top and the general results in the companies in which we tested this plan were much better than the results of the companies in which we didn't run the test.

Also, as an incentive, there was a great need for regular examinations. It was impossible for us to use examinations or tests on an extensive scale because of the large number of men involved and the great problems of grading the examinations and disseminating the results. However, before I left, we inaugurated what we called the "General Achievement Test" at the end of the training period, covering all subjects in which the men were trained while they were at our Command. This was most effective both in grading up the quality of the training given by the Company Commanders and the instructors, and also in getting the interest of the men.

Now, in closing, I'd like to dwell on the subject of the returning veteran, many of whom undoubtedly will enter your employ. I think you'll find him to be a pretty normal individual. If he proves to be a psycho-neurotic or emotionally unstable in any respect, he probably always has been, even before he got into the Navy or the Army, in spite of the careful screening of the recruiting officers. Cases of genuine combat fatigue usually are very hard to detect even by people in daily contact with the man who is suffering from combat fatigue. He has plenty of trouble, but as a rule he will take every precaution to prevent other people from being aware of his difficulties, most of which, I believe, occur at night, when he can't sleep. He also has trouble with his digestion and things of that nature.

I would say that by far the highest percentage of the men with whom I worked closely during my service in the Navy are just as normal as the men with whom I have worked in business. The best of them were continually concerned about the work that they might get into after the end of the war. They were sincere in every respect, and many of them studied, even in the most forward areas, to prepare themselves for the work they hoped to do after the war.

If I were to pick from the men who served with me and select those I would like to have working with me in business, I believe that I would have the finest group of clean youngsters that could be assembled any place in the world, and not one of them would give you any disturbing evidence whatsoever of the experiences he has had, even though he might be suffering severely from combat fatigue.

I would approach him as a man who has just left the position he held in civilian life at the time he went into the service, whether it were in business or in school, and I would give him credit for having matured a great deal since that time by reason of the experiences that he has had.

I would expect him to be completely sincere, and anxious to succeed, and not in any way affected by his experiences except as they may have broadened him and given him more mature judgement. If he doesn't fit this pattern, don't blame his experiences in the service.

It probably goes back to the man himself, whether he has ever suffered from combat fatigue or not.

Of one thing I think you can be sure. Given a reasonable amount of considerate handling and direction, and given the opportunity to learn something that will help him to be successful in business, I believe you can depend on the returning veteran to carry more than his share of the load.

These men are in the habit of doing more than their share, when the need arises. They are unspoiled by any philosophy of forty-hour weeks or minimum wage scales or overtime pay.

On board ship we would frequently break out a 50 or 200 hand working party at 2:00 or 3:00 o'clock in the morning, to load supplies or handle ammunition. These men always did this kind of work cheerfully and without grumbling and without any thought of reward.

I think this viewpoint is once more making itself felt in our daily lives, as a result of veterans getting back into civilian work.

The veteran has been away from life as we know it here for a long time and he is anxious to re-establish his place in this life because he knows it's a good life and he wants to be successful in it.

If in selecting your veterans you choose from the better half, you will pick your men from the most responsible group of ingenious young men in the world!

The Five Year Gap

(Continued from page 46)

and six hours is counted as half-time schooling. The amounts he receives are based on these proportions. The man who studies at a half-time schedule can spread each year of training over two years. During all of this time he is earning his salary from the company in a part time position. Thus the company is plugging the "five year gap" immediately and the man is getting the schooling he needs. The college graduate can secure a master of science degree in three or four years and the undergraduate can obtain his degree at a date that is not unreasonable. A complete four year curriculum can be complete in seven or eight years. About twenty to twenty five per cent of evening school enrollments throughout the country are ex-service men at the present time.

Part Time Day Study

The same regulations apply also to part time day study. The Veterans Administration does not differentiate between sunlight and artificial light under which to go to school. Due to difficulties of scheduling classes for students in various types of curricula and with various academic backgrounds, the opportunities are limited. Most three-hour lecture courses are traditionally scheduled on Monday, Wednesday, and Friday. Some schools are becoming so crowded that sections must be scheduled on Tuesday, Thursday, and Saturday. If the company be willing, the veteran can usually schedule a satisfactory part time list of courses in the day classes. Both day and evening part time study plans are effective in large urban centers where both jobs and transportation are available.

Co-operative Programs

Many corporations have had experience with the co-operative five year curriculum. It is gaining in popularity. The student, paired with a second man, alternately goes to college and works at the job for the company. As his education progresses, his responsibility and income rise. At the time of graduation, the employer has a man that is both educated and experienced. The employer has also the responsibility to see to it that the job has a training value that moves the man up the ladder of success at an ever increasing rate.

All of these programs depend upon the attitude of the employer toward advanced training for the employee. It is estimated that there is a shortage of nearly 500,000 scientists and engineers at the present time. This shortage is extremely acute in the age group represented by the returning veteran. The competition between corporations for desirable technically trained men will be keen and to those who make it possible for such men to succeed will go the best brains and ability in the land. College education for the returned G. I., without financial want, is the cornerstone of any program to meet the need.

Carbon Black

(Continued from page 44)

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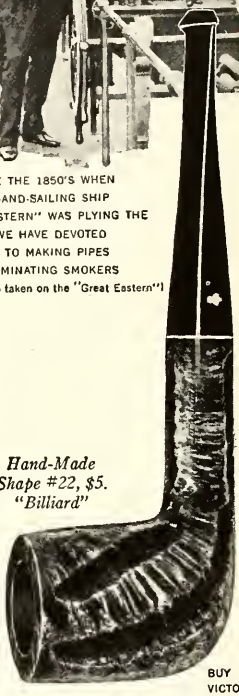
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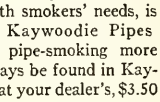
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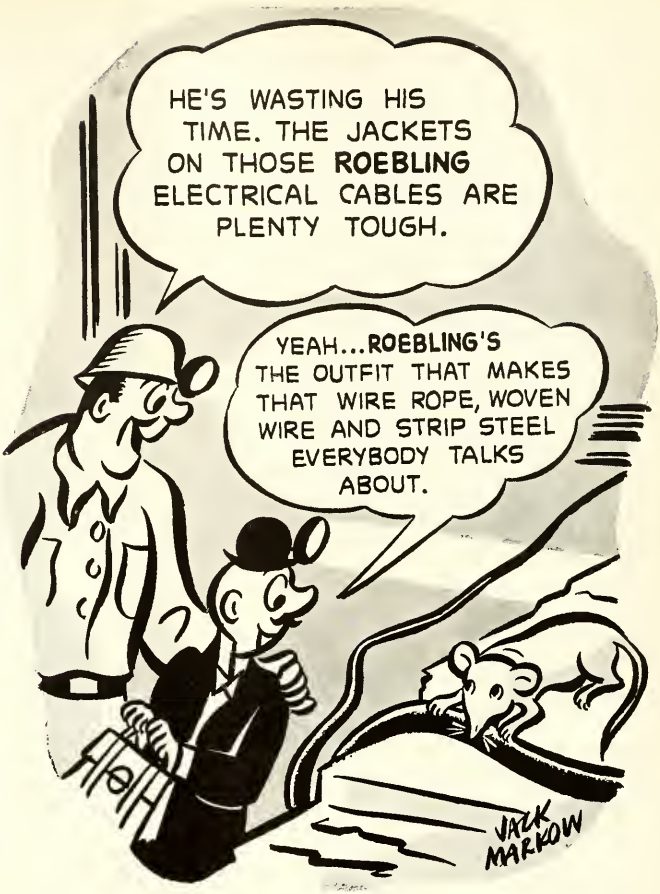
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(Continued from page 28)

become a large industry itself, added to the already complex chain of activities from mines to mills in the making of steel. It is inevitable that this incipient industry will rely to a great extent for necessary low costs on electrical machines.

Citizens of the United States still have iron in the bank. But it cannot all be cashed with equal ease. Having it as mineable ore, rich in quality and near the surface, is one thing. Having it in low grade hard rock, or deep in the earth is another. Inevitably, as the good ore tapers to exhaustion — within a relatively few years as we reckon the life of our nation—we must and will learn how to work and beneficiate these lean, hard ores, and do it cheaply. That calls for the thing we have in abundance — ingenuity and technical skill.

Industrial Research

(Continued from page 30)

laboratories and turn their long-term projects over to universities or research institutes.

Consulting Laboratories.—Consulting research laboratories have always been an important factor in the American industrial research scene. These laboratories are operated as service organizations, charging a fee for their services to their clientele in accordance with the program undertaken. These organizations are extensive throughout the United States and are typified by such well known ones as Arthur D. Little, Incorporated, and Foster D. Snell, in the East, and Miner Laboratories in Chicago. In addition, there exists a number of consulting organizations which actually do no research work but are skilled in the application of science and technology to industry and render consulting services in this regard.

Research Institutes.—Research Institutes are generally endowed, nonprofit organizations operated primarily to serve industry on long-term applied research projects. Typical of these is the Mellon Institute of Industrial Research at Pittsburgh and the Battelle Memorial Institute at Columbus, both of which were founded and endowed in the interests of research service to industry by the individuals, carried in the name of the institutions.

Within very recent years a modification of this plan of rerearch organization has been developed where the support comes not from the endowment created by an individual but by contributions from a large number of people who have the same objective in mind as the creators of the previously mentioned institutions. These latter organizations take on the aspects of not only being industrial research institutes but also regional research institutes. In other words, they are dedicated not only to service to the industries but to the development through scientific research of the resources of the areas in which they operate.

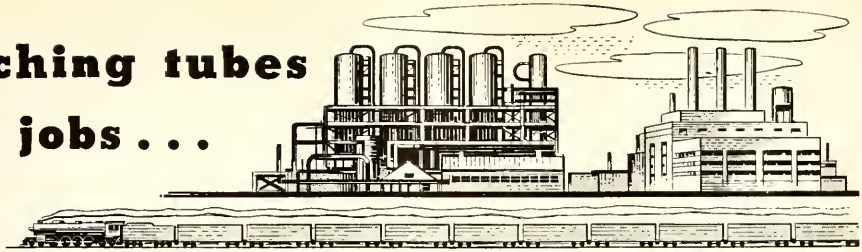
The Midwest Research Institute located at Kansas City, Missouri, and operating since January of this year is not only serving industrial organizations on their research problems but has undertaken a number of research projects in the interests of the development of the industry of the midwest area of the country. Similarly, the Southern Research Institute located at Birmingham, Alabama, was recently created to serve the South. Both of these organizations were established by rather substantial contributions coming from large numbers of people who were interested in the betterment of standards of living in the areas involved. In this way it is expected that as years go on endowments will be developed from broad support of people of all walks of life who have a regional interest. A third institution of this character is just being established in California and is known as the Pacific Research Foundation and one is being planned for the Pacific Northwest. The geographical location of these organizations and their extensiveness of operations are dependent upon comon natural resources and area economy and trade conditions.

Not being tax supported, all research institutes can enter into agreements with sponsors which provide for outright patent protection and keeping the results confidential where these features are desired. In the case of regional research projects patent rights are expected to belong to the institute sponsoring the program for licensing to interested manufacturers.

The research foundations of educational institutions have much in common with the research institute. For purposes of clarity, however, these are discussed under the classification of "Universities and Colleges."

Foundations and Councils.—The foundations of this classification refer to the numerous endowed or industry supported organizations which sponsor research. Typical of the endowed foundations working in public interest are Rockefeller Foundation, Carnegie Corporation, Carnegie Institute, the Engineering Foundation, and the Research Corporation of New York. The industry supported foundations and councils are increasing year by year and are typified by such organizations as the Nutrition Foundation, the Tanners' Council, Lithograph Research Institute, National Cotton Council, Sugar

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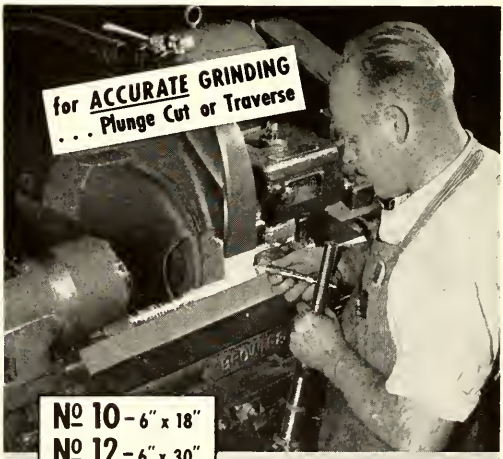
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Foundation, and the Iodine Foundation. Companies within the industry involved in each case make annual contributions to the program which in turn support research projects conducted at outside laboratories under the general supervision of the council or foundation involved. It is significant to note tha texpenditures in some cases reach a million dollars or more annually.

All of these are notable for the aid they have given, primarily in the support of fundamental research investigations in our educational institutions.

The National Research Council is included in this classification although its activities are much broader for it operates in many fields of which engineering is one. Not only is it the recognized national research clearing house but it also makes grants to various research agencies including universities and colleges. The National Research Council publishes from time to time an important directory under the title, "Industrial Research Laboratories in the United States," and has recently published a listing of research grants by industrial corporations to universities and colleges as well as to other research agencies. The Council also sponsored the organization of the Industrial Research Institute which is a national organization of industrial research directors and executives.

Professional Societies.— Most of our national scientific and engineering societies have funds which are granted usually through a research committee, to institutions equipped to do research of basic importance to the society. Such committees may also serve in correlating national and international research activities having a bearing on the functions of the society. In many instances a committee of one society will work jointly with a committee of one or more societies in the sponsoring of research having mutual interest. Much of our engineering progress in past years has been made possible by the activities of this group.

Universities and Colleges.—The very idea of research comes from our universities and colleges which mothered it long before American industry had much interest in it. Research has been in the past and is today a primary factor in higher education, thereby enabling the universities to furnish industry with men possessing knowledge not only of the underlying scientific facts and theories but of the methods and techniques of research. From the universities also flows much of the basic knowledge of science on which modern technical industry has been built and will build in the future.

Research work in our educational institutions today is carried on in one or two ways: either as individual activity in a field in which the worker is interested and urged on by his enthusiasm for his particular subject, or as part of a sponsored plan. In any event the reputation of an institution seems to depend to a large extent upon its research productiveness and most institutions encourage research by their faculties and graduate students, some even tending to make it a prerequisite for appointment.

Several plans for sponsored research in our educational institutions are in existence today. In one instance the worker or faculty member is given a grant, either by the institution or by an outside agency. It is generally conceded that most of the research grants that go to our universities and colleges today are given not because of the standing of the institution entirely but because of the reputation of a particular faculty member who has unusual capabilities and facilities for the carrying on of research in the particular field in which the outside agency making the grant is interested.

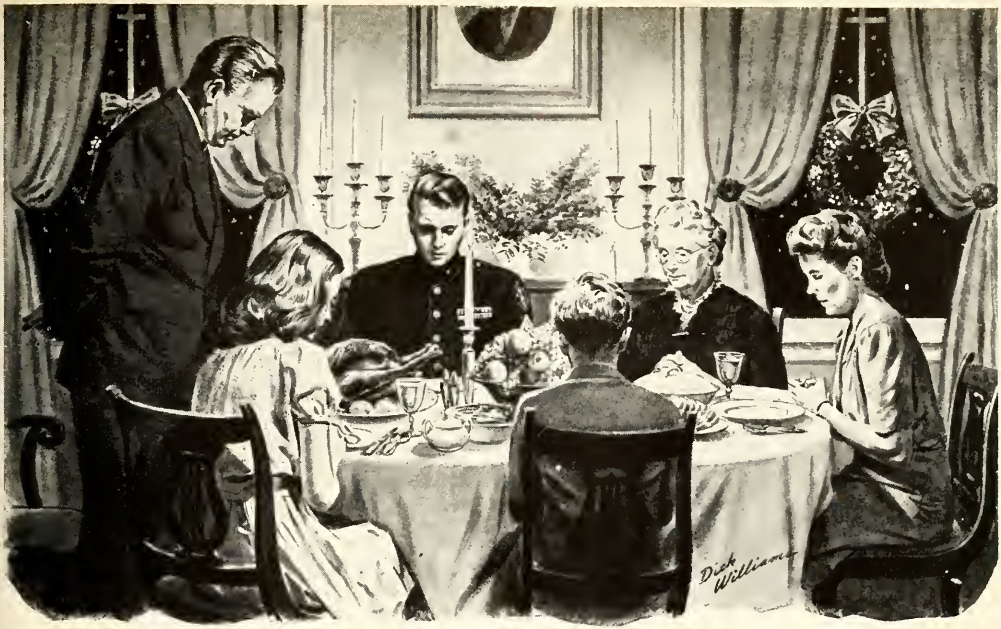
A second case refers to those institutions which receive support from governmental agencies for work in specific fields. These are mainly state or tax-supported institutions which function partly to render research services in agriculture and the mechanical arts to their communities through grants from the state or government.

A third instance of a sponsored plan covers organized research in educational institutions and often takes the form of an experimental engineering station. Typical is the Engineering Experiment Station, University of Illinois. An organized research program of this kind offers many incentives for industrial participation as evidenced by the fact that many of these organizations receive substantial research support from individuals, corporations, associations and other research agencies.

Universities and colleges usually prefer to carry on research under circumstances where patents are not involved and the publication of results is desired by all parties. This is usually the case of all fundamental research, certain industrial research sponsored by manufacturing associations, and research made possible by grants from societies and other agencies. However, complications have arisen under this system where a sponsor wants patent protection and the results kept confidential. To meet this situation many of our universities have in recent years created affiliated nonprofit research corporations operated under the administration of the university. Typical of these organizations is the Research Foundation of Ohio State University, the Research Foundation of the University of Wisconsin, the Purdue Research Foundation, and The Institute of Research of Lehigh University. There are many others, of course, and new ones are being established in increasing numbers. Generally speaking, these foundations are placed under a director who establishes contacts with industry and other grant-giving research agencies and through faculty coordination research projects are undertaken by agreements which cover patent policies and publication rights.

Armour Research Foundation of Illinois Institute of Technology comes under this classification with the modification that its staff comprises primarily full-time personnel engaged to work on research projects exclusively. Further it gives full patent rights to its sponsors whereas most of the others give varying degrees of patent protection.

The increased tendency to organize research activities in educational institutions during the past decade has been brought about by the necessity of adopting well defined policies in regard to inventions made by faculty members. Some have predicted that in another ten or fifteen years all scientific educational institutions will have clearly defined patent policies. An unusually excellent treatise of this sub-



What's the other thing we ought to do this Christmas?

FOR the last four years, the Christmas phrase "Peace on earth, good will to man" has had a pretty hollow, bitter ring.

This year, it won't.

And surely, one thing each of us will want to do this Christmas is to give thanks that peace has finally come to us—both peace and victory.

One other thing we ought to do:

In our giving, this year, let's choose—first—the kind of gift that helped to bring us peace and victory and will now help us to enjoy them.

★

Victory Bonds take care of the men who fought for us—provide money to heal them, to give them a fresh start in the country they saved.

Victory Bonds help to insure a sound, prosperous country for us all to live and work in.

Victory Bonds mean protection in emergencies — and extra cash for things we want to do ten years from now.

★

Choose—first—the finest gift in all the world, this Christmas.

Give Victory Bonds!

Give the finest gift of all – VICTORY BONDS!

ECONOMY FUSE AND MANUFACTURING COMPANY

General Offices — Greenview at Diversey Parkway CHICAGO, ILLINOIS, U. S. A.

★*This is an official U. S. Treasury advertisement—prepared under auspices of Treasury Department and War Advertising Council*★

ject is given in "University Patent Policies" by Richard Spencer, Lecturer on Patents, Northwestern University Law School, and published in 1939.

Federal Government.—Prior to the war years (1940-1945) the Federal Government held a very secondary place to industry in research activity. If it had not been for the war the discussion of this classification could have been dispensed with simply with the following few comments which give the picture for 1940:

"A basic activity of any government is to carry on research which has a bearing on the general welfare of its people. The budget for research by our national government agencies during the year 1940 was approximately $69,000,000 and was distributed about as follows:

Engineering	36%
Surveys	16%
Physical Sciences	4%
Natural Sciences	39%
Public Health	5%
Total	100%

"Government research generally covers those fields which private industry either has no incentive or no reason to enter on a broad scale. It is the kind of research that is carried on to improve health, increase our national security, and conserve our natural resources. Typical of these fields are national defense, mining and agriculture. The outstanding bureaus which are most widely known are the Bureau of Standards and the Bureau of Mines. The United States Department of Agriculture recently created four regional research laboratories to work on the agricultural problems of their respective regions."

Out of the war years there arose a very complex and even revolutionary situation as far as research is concerned. Almost overnight peaceful pursuits were dropped and with almost no exception scientific personnel and research facilities were geared to the war program. The government research budget of $69,000,000 in 1940 grew to approximately $720,000,000 in 1944 and for a total of approximately $1,800,000,000 for the five years, inclusively. Only a small portion of these funds was spent in government laboratories, the large portion going to the laboratories of industry, universities and colleges, research institutes, and private consultants in the form of underwritings of specific war research projects. In these arrangements the government was represented by several federal war research agencies created for that purpose.

The results have been most gratifying and it is now generally accepted that a major lesson learned is that highly efficient research productivity results from the use by the government of private, industrial and institutional laboratories throughout the country.

The experience has also taught us the real need for greatly increased activity in fundamental or pure research and the need for greatly expanded means of fostering scientific education for American youth having proper qualifications. It is not believed that these objectives can be accomplished by prewar methods and that government support is necessary. Several proposals for the promotion of scientific research are now in Congress, the two most noteworthy being one providing for a "National Research Foundation" and based on the proposals of Dr. Vannevar Bush, Director of Office of Scientific Research and Development, in his report to the President entitled, "Science—The Endless Frontier," and one providing for a "National Science Foundation" containing principles that the Subcommittee on War Mobilization of the Senate Military Affairs Committee deems desirable. It is not the purpose of this discussion to cover their relative merits. In some respects they are similar but in others they are in direct conflict. Strong controversial phases of the bills relate to the methods of administration and to patent rights. In any case they represent a trend —a trend which will bring very substantial financial aid to the American research scene through all types of laboratories throughout the land. Research in the United States is destined to become a billion dollar a year industry and is today only limited by the shortage of personnel and facilities.

All for the reason that science is truly the endless frontier.

Power Conference

(Continued from page 22)

Wednesday, April 23, 1946 (continued)

for the Rio Negro Project. Kenneth W. Jarvis, Consulting Engineer, Winnetka, Ill.

(b) The Use of Silicone Insulation. G. L. Moses, Section Engineer, Transportation and Generator Division, Westinghouse Electric and Manufacturing Co., East Pittsburgh.

(c) The Application of Rotating Regulators. L. T. Rader, Illinois Institute of Technology.

(d) Discussion.

Thursday, April 4, 1946

9:00 A.M. Parallel Operation and Interconnection. Chairman: E. W. Kimbark, Northwestern University.

(a) Damper Windings for Waterwheel and Diesel Generators. W. L. Ringland, Electrical Engineer, A.C. Design Division, Allis-Chalmers Manufacturing Co., Milwaukee.

(b) Power Exchange in Interconnected Systems. C. W. Mayott, Hartford Electric Light Co., Hartford, Conn.

(c) Discussion.

9:00 A.M. Developments in Space Heating. Chairman: Ralph E. Turner, Editor, POWER PLANT ENGINEERING, Chicago.

(a) Radiant Heating. T. Napier Adlam, Vice President, Sarco Co., Inc., New York.

(b) Industrial Applications of the Heat Pump. Philip Sporn, Vice President, American Gas & Electric Service Corp., New York.

(c) Discussion.

10:30 A.M. Hydro Power No. 1. Chairman: F. M. Dawson, State University of Iowa.

(a) Present Status of the Proposed Hydroelectric Development of the St. Lawrence River. Carl Giroux, Principal Assistant to the Chief of Engineers, Washington, D. C.

(b) Hydroelectric Power in the Missouri Basin. B. H. Greene, Regional Engineer, Federal Power Commission, Chicago.

(c) Discussion.

12:15 P.M. Joint Luncheon with A.I.E.E. Chairman: J. F. Calvert, Chairman, Chicago Section, A.I.E.E. Speaker: D. C. Prince, Vice President General Electric Co., Schenectady. "Promotional Engineering."

2:00 P.M. Insulation Problems on Power Systems. Chairman: C. E. Bauman, Chairman, Power Group, A.I.E.E.

(Sponsored and arranged by the Power Group, Chicago Section, A.I.E.E.)

(a) Field Testing of Insulation. A. L. Brownlee, Commonwealth Edison Co., Chicago.

(b) Transients in Electric Power Systems. H. A. Peterson, General Electric Co., Schenectady.

(c) Review of Present and Future Conditions in the Cable Field. R. J. Wiseman, Chief Engineer, The Okonite Co., Passaic, N. J.

(d) Discussion.

Economies

Born Of War Industry Have Their Rewards TODAY...

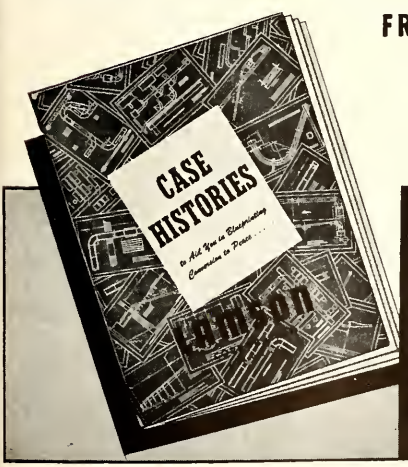
● Fearful of being "too late with too little," American industry won its race against time. Quantity and quality surpassed the hopes of all but the most courageous and progressive.

One of the contributing factors to victory was the *general advancement in mechanical materials-handling*, and most particularly in routing materials in process through successive stages of manufacture. Substantial savings in manpower, time and costs accrued. Production consistently increased, meriting a steady flow of "E" awards.

Lamson Conveyors, through many ingenious applications, devised by Lamson engineers, showed industry throughout the length and breadth of the country, new speeds and economies in materials-handling.

The rewards of Lamson achievement are now available to you . . . and in practice are essential to the competition which is following reconversion.

To Assist In Today's Planning, We'd Like To Send The FREE BOOK "CASE HISTORIES"...



It will aid in blueprinting conversion to peacetime conditions . . . come inside some of America's greatest industries with us . . . and see how they will handle the problems of increased output at lower costs. Write for your copy today.

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950 Lamson St., Syracuse 1, N. Y.
Please send me a copy of your reconversion booklet, "Case Histories."

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College.....
Address.....
City and Zone..... State.....

2:00 P.M. Diesel Power. Chairman: R. E. Summers, University of Minnesota.

(a) Exhaust and Intake Mufflers and their Effect on Performance of Diesel Engines. Robert W. Huddle, Development Engineer, Burgess-Manning Co., Chicago.

(b) Effect of Superchargers on Diesel Performance. Ralph Miller, Nordberg Manufacturing Co., Milwaukee.

(c) Discussion.

3:30 P.M. Gas Turbines No. 1. Chairman: D. L. Arm, Iowa State College.

(a) Where the Gas Turbine Stands Today. L. N. Rowley, Managing Editor, and B. G. A. Strotzki, Assistant Editor, POWER, New York.

(b) Linear Relationships in Gas Turbines. John T. Rettaliata, Illinois Institute of Technology.

(c) Discussion.

6:45 P.M. "All Engineers" Dinner. Informal. Grand Ball Room. (Ladies Invited.)

Speaker: Lieutenant General Raymond A. Wheeler, Chief of Engineers, U. S. Army, Washington, D. C.

Friday, April 5, 1946

9:00 A.M. Gas Turbines No. 2. Chairman: H. O. Croft, State University of Iowa.

(a) The Gas Turbine in Industry. J. R. Carlson Westinghouse Electric and Manufacturing Co., Philadelphia.

(b) Arrangements Pending.

(c) Discussion.

9:00 A.M. Hydro Power No. 2. Chairman: Ben G. Elliott, University of Wisconsin.

(a) Spillway Gate Operation to Prevent Erosion Below Dams. Arno Lenz, University of Wisconsin.

(b) The Objectives and Benefits of the Wisconsin Valley Improvement Co. M. W. Kyler, General Manager, Wisconsin Valley Improvement Co., Wausau, Wis.

(c) Discussion.

10:30 A.M. General Session. Chairman: F. A. Faville, Faville-Le Vally Corp., Chicago.

Subject: Your Nation's Future, an Engineering Problem.

Speakers: Melvin J. Evans, Management Engineer, Evans Associates, Chicago; L. J. Fletcher, Director of Training, Caterpillar Tractor Co., Peoria, Ill.; Samuel R. Harrell, Executive Vice President, Acme Evans Co., Indianapolis; A. A. Potter, Dean of Engineering, Purdue University; Roy V. Wright, Vice President, Simmons-Boardman Publishing Co., New York.

12:15 P.M. The Conference Luncheon. Chairman: W. A. Lewis, Illinois Institute of Technology.

Speaker: J. A. Hutcheson, Associate Director, Westinghouse Research Laboratories, East Pittsburgh. "Radar," Demonstration and Lecture.

2:00 P.M. Industrial Power Plants. Chairman: H. L. Solberg, Purdue University.

(a) Modernization of Small Power Plants. C. M. Garland, Consulting Engineer, Chicago.

(b) Smoke Abatement in Small Power Plants. Carroll F. Hardy, Chief Engineer, Appalachian Coals, Inc., Cincinnati.

(c) Extraction Turbines for Industrial Power. L. E. Newman, General Electric Co., West Lynn, Mass.

(d) Discussion.

3:45 P.M. Fuels. Chairman: H. B. Dirks, Michigan State College.

(a) Coal Handling from Bunker to Stoker. A. J. Stock, President, Stock Engineering Co., Cleveland.

(b) Coal as The Fuel for the Gas Turbine. John I. Yellott, Director of Research, Locomotive Development Committee, Baltimore, and A. D. Singh, Institute of Gas Technology, Chicago.

(c) Discussion.

3:45 P.M. Industrial Load Supply. Chairman: W. A. Lewis, Illinois Institute of Technology.

(a) Electromagnetic Processes of the Atomic Bomb Project. R. R. Wisner, Assistant Chief Electrical Engineer, Stone and Webster Engineering Corp., Boston.

(b) Electrical Power Supply for Steel Mills. F. W. Cramer, Carnegie-Illinois Steel Corp., Pittsburgh.

(c) Special Problems in Industrial Power Supply. R. L. Witzke, Westinghouse Electric and Manufacturing Co., East Pittsburgh.

(d) Discussion.

MARSH & McLENNAN

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LONDON VANCOUVER HAVANA
MONTREAL

Established 1871



THE FLAME THAT CUTS *Through Sea and Steel*

Men-of-war that "died" at Pearl Harbor lived again to fight at Omaha beach and Leyte. No small measure of credit for their resurrection belongs to the modern techniques of underwater cutting with the oxy-hydrogen flame and underwater welding with the electric arc. These methods are serving the nation's needs in wartime, and are also opening the way to new peacetime accomplishments in submarine salvage and construction.

Air Reduction has played a leading part in designing and manufacturing equipment for underwater cutting, as part of its program of progress which has given the world many new developments in welding, cutting and other related methods for modern metal-working.

The operating subsidiaries of Air Reduction Company, Inc., are:

AIR REDUCTION SALES COMPANY
MAGNOLIA AIRCO GAS PRODUCTS CO.
Industrial Gases, Welding and Cutting Equipment

NATIONAL CARBIDE CORPORATION
Calcium Carbide

PURE CARBONIC, INCORPORATED
Carbonic Gas and "Dry-Ice"

THE OHIO CHEMICAL & MFG. CO.
Medical Gases—Anesthesia Apparatus—Hospital Equipment

WILSON WELDER & METALS CO., INC.
Arc Welding Equipment

AIRCO EXPORT CORPORATION
International Sales Representatives of these Companies

AIRCO **AIR REDUCTION**
60 East 42nd Street, New York 17, N. Y.



Low Speed Polisher No. 1505-2

. . for accurate final polishing

THE BUEHLER line of specimen preparation equipment includes —

CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • POLISHERS • POLISHING CLOTHS AND ABRASIVES

Low speed polishing is increasingly popular for the final step, particularly where soft non-ferrous metals are encountered. The production of smooth polished samples with a minimum of surface scratches and disturbed metal is the outstanding feature of this low speed Buehler Polisher No. 1505-2. Built to operate at selective speeds of 150 r.p.m. and 250 r.p.m. through a positive gear head drive housed in an oiltight base, this polisher represents the highest development in equipment for precision finishing of specimens. This polisher is also perfectly suited to the wax lap or lead lap polishing technique preferred by many metallurgists.

The 8" diameter polishing disc is attached to a countershaft by a tapered sleeve. This tapered fit and long span between bearings assures smooth operation. The motor is ¼ h.p. single phase ball bearing, operating on 110 V., 60 Cycle AC current. Shipping weight, 80 lbs.





Buehler Ltd.

A PARTNERSHIP

METALLURGICAL APPARATUS

165 West Wacker Drive, Chicago 1, Illinois

To The

YOUNG ENGINEERS OF AMERICA

To those young engineers who are in the service—those who are at the drafting boards of industry—those who are preparing themselves for the engineering profession:

The "good-will" which attaches to a good name or trade-mark has often been appraised at many millions.

For the public places reliance and trust on those names which down through the years have proved they will faithfully reward that confidence.

The products the public trusts are the ones they buy. Where their heart is—there their business follows.

Such a tremendously valuable asset is not built up overnight. It comes only after arduous years of toil—of many disappointments—many triumphs and achievements. And once attained—an equally strong and effective effort must be constantly maintained to guard and protect the reputation thus earned.

Quality of the product—standards of workmanship—must be kept at the highest possible level—in line with the famous name which it bears. Performance in the hands of the user must live up to the highest standards he has been led to expect.

Industrially, one of the great names in America—a name recognized for its foresight, courage, progress and leadership, is the name Timken. The whole world moves forward on these advanced products.

You'll do well to learn the many benefits of Timken Bearings. For Timken Bearings have indeed been of prime importance in making life easier, smoother and better for all humanity.

The Timken Roller Bearing is one of the basic factors which made possible the efficient performance of our huge war machine. It will be vitally important to our vast peacetime economy at which the whole universe will marvel.

In addition to Timken Bearings there are Timken Alloy Steels used for many highly specialized applications and Timken Rock Bits which have revolutionized modern mining and construction.

The Timken Company has spent millions in research and technological improvements so that millions of Americans may enjoy a better life—so that engineers like yourself can rely implicitly on each Timken product—each Timken recommendation.

Engineers have at their disposal all of the facilities of this organization which is the world's foremost manufacturer of anti-friction bearings.

This company offers unlimited opportunity to many young engineers. Maybe you might like to come with our organization. We will welcome applications from engineers who feel that they may fit into a company such as ours.

The old proverb—"Deviate an inch and you lose a thousand miles"—is a sound thought for young engineers to bear in mind. There is one thing as steadfast as the North Star—Timken Bearings are steadfast in dependable performance.

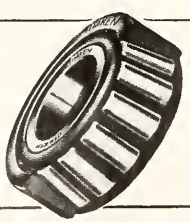
Everyone knows dependable performance is a basic requirement of mechanized America. Millions of wheels and shafts are turning faster, more accurately, more freely, and longer, because of the inherent qualities of this precision product.

It has been truly said that the trade-mark Timken incorporates all there is in Bearings. See that the trade-mark "TIMKEN" is on every bearing you use.

THE TIMKEN ROLLER BEARING COMPANY

CANTON 6, OHIO

Copyright 1945 by The Timken Roller Bearing Co.

TIMKEN  **BEARINGS**



Copyright 1946, Liggett & Myers Tobacco Co.

ILLINOIS TECH ENGINEER

SPRING 1946





A "Sound" Idea For Record Performance

Everything that contributes to greater enjoyment of music is welcomed with open arms by millions of Americans. That is why the new plastic phonograph records are an instant hit. They reproduce the music of great artists and orchestras with truly amazing range, clarity and fidelity—and without a "scratch" or other surface noises.

Making such records is a precision, mass-production job requiring fine molds of great accuracy. One part of the plastic molding process—releasing the pressings from the mold—is greatly facilitated by the use of stearates or metallic soaps, employed as dusting materials, mold lubricants, and processing aids because of their fine silky texture. And it is these same properties, plus others equally interesting, that are making this group of chemicals highly useful in a variety of industrial processes. For example, they are being used widely in making special oils and greases, because of their "bodying" qualities. They are also used as mold lubricants in the manufacture of rubber products, and they impart desired adhesive qualities to face powders..."flatness" and anti-settling characteristics to paints...water resistance to fabrics and to concrete, brick and stucco.

Increasing the quality and utility of stearates is one of the many projects in which Witco Chemical Company is actively engaged. Through research and expanding production facilities, Witco has helped to make aluminum, zinc, magnesium, calcium and barium stearates the versatile "tools" of progress they are today. This is part of the broad service in chemicals, oils, pigments, waxes and asphalt specialties Witco offers to the rubber, paint, printing ink, plastic and other industries. If you have a material problem in these fields, Witco's modern technical service and research facilities can give you reliable assistance.

• • •

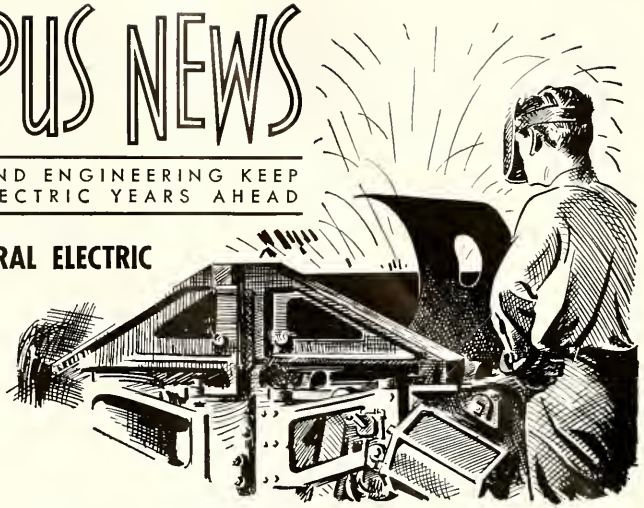
Witco Chemical Company, 295 Madison Ave., New York 17, N. Y. Offices in Boston; Chicago; Detroit; Cleveland; Akron...London, England.

Witco Chemical Company

MANUFACTURERS AND EXPORTERS

CAMPUS NEWS

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD



AIR CONDITIONING AT GENERAL ELECTRIC

NOW that the war is over, many builders and home owners are considering installing some form of air conditioning or automatic heating equipment—or both. Industrial plants are now finding new uses for air conditioning and refrigerating equipment daily; activity in this field was tremendously accelerated during the war. In the light of these conditions, it can be said that a man who is seeking a career should find in this field ample opportunity to learn a business and establish himself.

Heating and Cooling

Air conditioning has grown into a steadily increasing business. In spite of the depression of the early thirties and the expense of making and installing equipment, General Electric and other manufacturers showed their confidence in air conditioning by developing and placing on the market many kinds of air conditioning equipment from giant units for stores and theaters to small units for room conditioning.

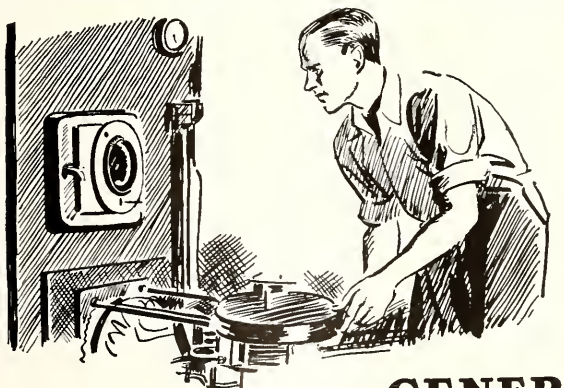
Paralleling the development of gas and oil as furnace fuels was the development of furnace electrical control systems. The market for automatic heating will be huge. Commercial refrigeration will be important as long as people want food to eat. And commercial air conditioning will continue to find new uses.

"Slide Rule" or Sales Engineering

Manufacturers need good engineering talent—for designing, application, and for commercial engineering activities. If a man feels that he has some talent for influencing people as well as manipulating a slide rule, he might consider becoming a sales engineer, selling air conditioning and refrigerating machinery, or becoming an installation and service manager.

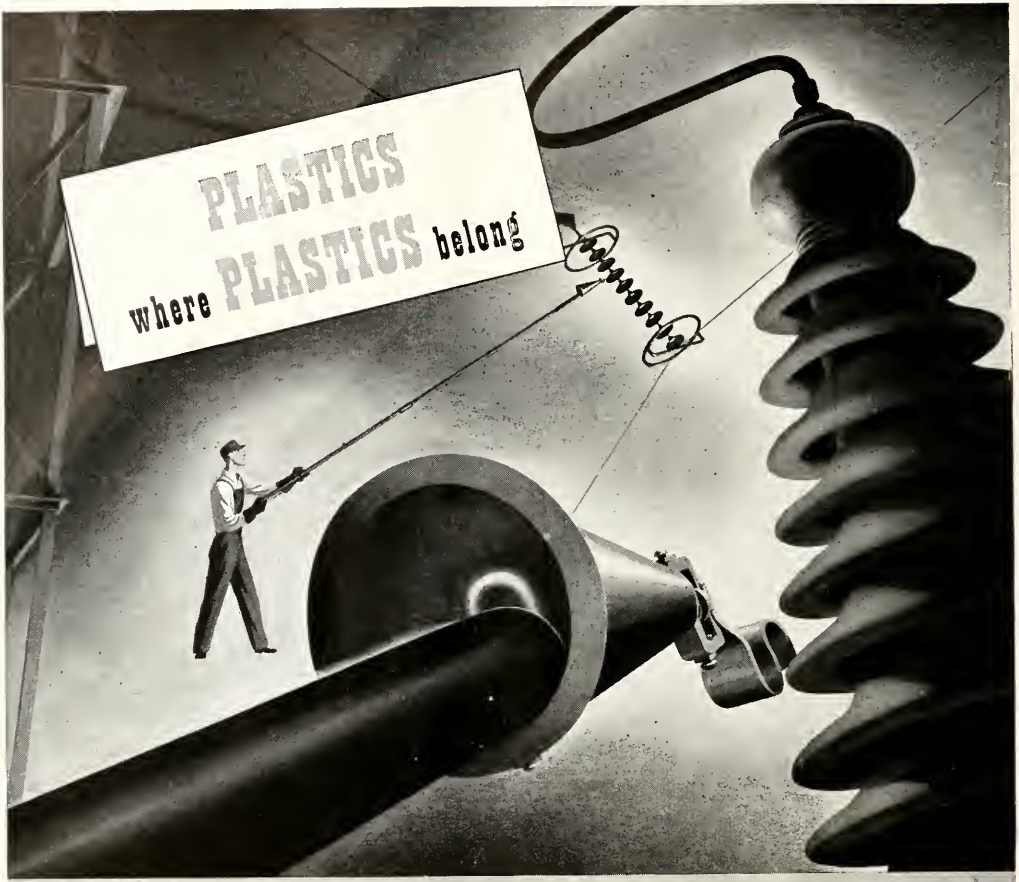
The sale of air conditioning and refrigeration equipment to factories and mills has always required competent sales and application engineers. Here the market is expanding so rapidly that contractors may find it advisable to consider the use of "practical" engineers who have apparent but unpracticed sales ability.

The scope of activity is very broad, and hundreds of opportunities will be open for both experienced and inexperienced men. *This advertisement is one of a series discussing opportunities for young men in fields in which General Electric has made important contributions. General Electric Co., Schenectady, N. Y.*

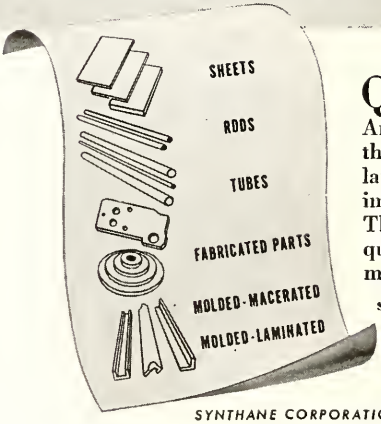


GENERAL ELECTRIC

953-111C-211



Using High Insulation Resistance



QUESTION (and a burning one): "Is the line alive?" Answer: "Yes, if the lamp on the end of 'stick' glows." The lamp works by contact or proximity with high tension lines. The "stick," protecting the inquirer from high voltage, is machined from lengths of Synthane tubing . . . a good example of using plastics where plastics belong.

Synthane has high insulation resistance, resists physical abuse, and its uniformity—vital in this application—can be counted on in quantity manufacture.

SYNTHANE TECHNICAL PLASTICS • DESIGN • MATERIALS • FABRICATION

SYNTHANE CORPORATION, OAKS, PA.

SYNTHANE



You just THINK you're touching aluminum, mister!

Pick it up . . . in your bare hands . . . anything made of aluminum. Your cigarette box. A saucepan. The foil on a chocolate bar.

You're not touching aluminum. You *never* have, never will.

The reason is very simple. Aluminum is constantly covered with the thinnest of thin "skins". It is Aluminum Oxide. You can scrape it off, but it re-forms immediately. In a split second.

This—the scientists at Alcoa's Aluminum Research Laboratories learned many years ago . . . but they didn't stop there. They wanted to know what could be done to this "skin" . . . how it could be made thicker, thinner, harder, porous . . . so that Aluminum products could be more useful and serviceable.

Out of this Alcoa research on the "skin" of aluminum have come many new things. Aluminum pistons of porous "skin", to hold oil. Aluminum trays of lush lustre that won't tarnish—ever. *Colored* aluminum—the color dyed right into the "skin".

Yes, Alcoa has found many ways of not only controlling this "skin" but also of making aluminum better and more versatile in many, many ways . . . *but the search still goes on* and always will.

This *search* calls to young men of science and engineering . . . and spells new opportunity to salesminded men of tomorrow.

The next time you pick up . . . in your bare hands . . . anything made of aluminum, say to yourself, "What *new* could I make this light, strong, durable metal do for man . . . some day?"

ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN **ALUMINUM**

CONTRIBUTORS AND CREDITS

Walter Lawton, chief photographer for Armour Research Foundation caught the cover picture in one of the research laboratories of Illinois Institute of Technology. He made many of the photographs used to illustrate the Foundation's Annual Report. All of the illustrations used in Dr. Luckhardt's article were taken in the doctor's study by Mr. Lawton.

Joseph Palma, Jr., A. '32 was a designer of exhibits at the 1933 Century of Progress Exposition in Chicago. His career in product designing began with Montgomery Ward & Co. where he acquired a vast background in a variety of mediums. After acting as head designer for a year and a half, he, in association with W. C. Nichols, formed his own firm.

During the war he was research engineer for Forest Products Laboratory in Madison, Wis., where he conducted strength studies in aircraft plywood. With the cessation of hostilities, he had reestablished with his associates the firm of Product Designers, of which he was Design Director. Palma recently opened his own office, at 6831 West 34th Street, Berwyn, Ill.

Dr. Stephen Sargent Visher, Ac. '06, has been Professor of Geography at the University of Indiana since 1919. He is a Fellow of the Geology Society of America, a member of the American Meteorological Society, the Association of American Geographers, and the Geographic Association, among others. He has been honored by most professional and honorary groups in his field.

Dr. Visher is the author of books on climatic change, economic geography, and natural resources; he has also written many articles and several tracts on related subjects. He has conducted governmental surveys in various parts of the world and his reports are part of the official records.

The recent coal shortage makes Dr. Visher's article particularly timely because of the general interest in fuel consumption at the moment.

See CONTRIBUTORS on Page 6

VOLUME 11 • NUMBER 3 • SPRING, 1946

ILLINOIS TECH ENGINEER

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WAYNE D. ADAMSON, JR., *Editor*

ALUMNI SECTION

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HARRY CARTER, *Associate*

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A. J. R. Curtis, M.E. '10; G. H. Von Gehr, E.E. '28; Major General C. L. Bolte, Ch.E. '17.

Pres. H. T. Heald; Major General C. L. Bolte, Ch.E. '17; James D. Cunningham (trustee); G. H. Von Gehr, E.E. '28.





Dean Rogers receives one of recognition awards also presented to Prof. McCormack, Finnegan and Tibbals.



Old Guard—Standing, Left to Right: N. M. Loney, M.E. '97; D. Roesch, M.E. '04; J. T. Wadsworth, Ac. '97; C. P. Rawson, A. '99; R. H. Rice, E.E. '97; J. M. Humiston, E.E. '98; S. J. S. Stanton, A.A. '02; P A. Rising, M.E. '98; W. F. Sims, E.E. '97; A. M. Jens, E.E. '04; W. S. Taussig, E.E. '03. Seated, Left to Right: H. M. Stenn, E.E. '03; A. Wagner, E.E. '03; J. C. Peebles, E.E. '04; C. T. McDonald, E.E. '04; M. B. Wells, C.E. '94; E. D. Merry, E.E. '03.

DEDICATION OF ALUMNI MEMORIAL HALL



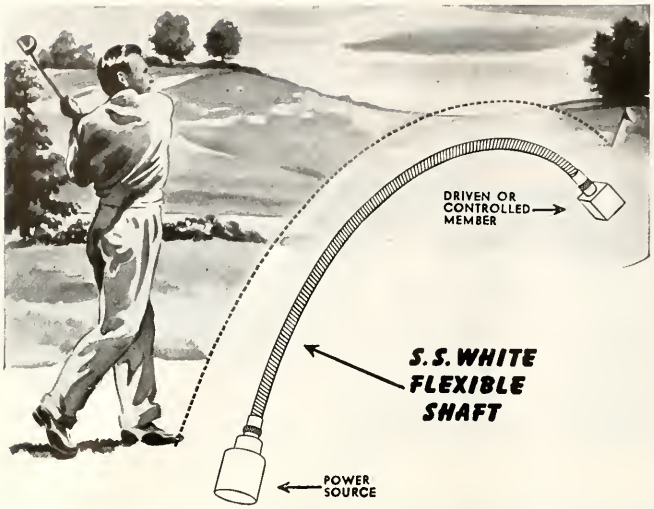
Pres. H. T. Heald, Vice Admiral Louis E. Denfeld, distinguished guests and members of the Board of Trustees.

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Interior of Main Hall, Alumni Memorial Hall at Dedication Services, May 29, 1946.



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CONTRIBUTORS AND CREDITS

Dr. Arno Benedict Luckhardt is one of America's most eminent physiologists. He has served on the faculty of the University of Chicago for more than thirty years. He is past president of the American Physiological Society, a member of the International Anesthesia Research Society, the Institute of Traumatic Surgery, the Federation of American Societies for Experimental Biology, and many other professional and honorary organizations.

Dr. Luckhardt is co-discoverer with J. Bailey Carter, of ethylene gas as an anesthetic agent. He has conducted lengthy research in the physiology of the parathyroid glands and also in gastric and pancreatic secretion. Aroused by the lack of information on the beginnings of modern medical technology, Dr. Luckhardt determined to trace the faint clues scattered through the writings of early practitioners—and found a hobby.

In pursuit of his unusual hobby, Dr. Luckhardt has found the work of the artist—the etcher, the engraver, the sculptor—and that of the physician and/or surgeon bound inextricably in the data and mechanical devices he has retrieved from obscurity. The photographs illustrating the talk he has so generously given ILLINOIS TECH ENGINEER permission to print will suggest the validity of his contention.

Philip W. Swain is the Editor of McGraw-Hill's magazine *Power*. He has written many authoritative articles on mechanical engineering, and is particularly at home when he writes or talks on power engineering, his field of specialization. His talk, "A Review of Atomic Energy for Power Engineers" attracted much attention in the daily press at the time it was delivered at the 1946 Midwest Power Conference in Chicago.

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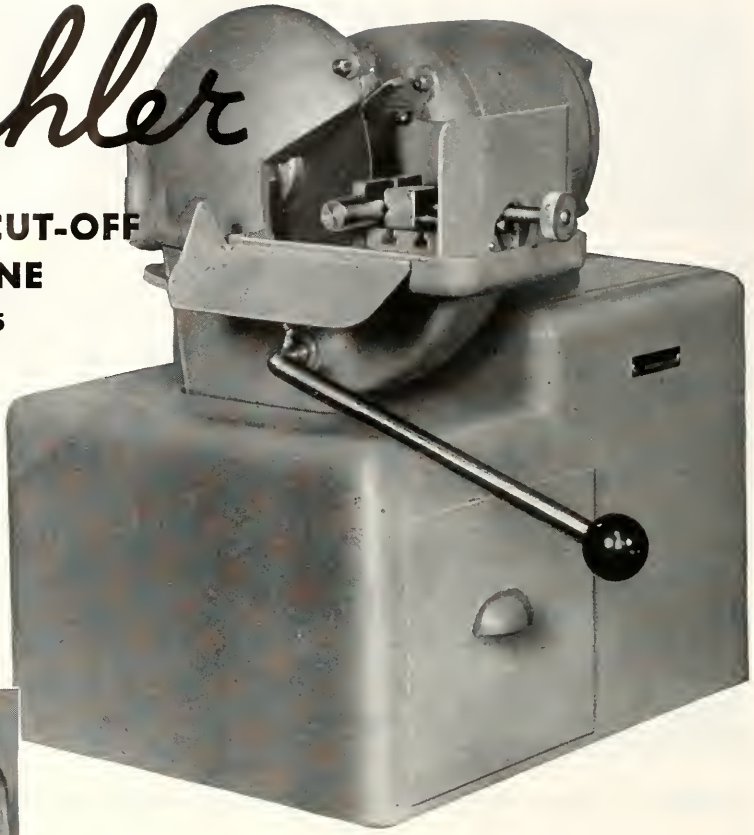
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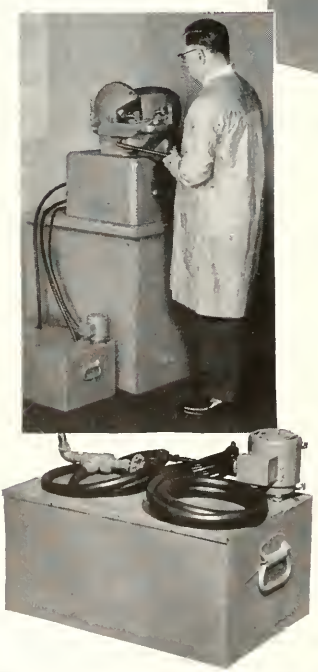
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THE AUTHOR

FACE LIFTING...

for Increased Sales

The Work of the Industrial Engineer

BY JOSEPH PALMA, JR., ARCH. '33

IT IS NOT STRANGE that an article on industrial design should appear in an engineering magazine since the welding together of the work of both engineer and designer is today more than ever an essential in our competitive enterprise. There is almost no product sold in the open market which could not benefit by the sympathetic cooperation between both these creative agents.

As engineers, you are entirely familiar with your part of the work, and you have for a long time handled the whole job from mechanical function to physical, external appearance. Often enough the external contours have been determined by some draftsman whose sole job was to see that the part could be easily cast, quickly assembled and so forth—with the least thought given to aesthetic satisfaction. Today, the satisfaction of aesthetic demands is the responsibility of the industrial designer. Allow me to define and give you some insight into his work.

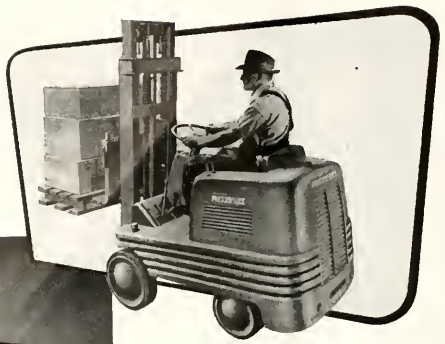


A functionally designed household scale — large, easily-read dial in base allows layer calibrations with complete visibility. Dished top aids in holding materials being weighed in place. Top surface turns for adjustments to zero. Design by the author. Engineering design by Max E. Toby, San Francisco.

Franciscan Ware "Metropolitan" pattern, originally developed for the Metropolitan Industrial Arts Exhibit in 1940, follows the principle of underlying geometric logic, found in all this artist's work. Of particular interest is the graceful functional handle design. Designed by Morris Saunders, New York.



These illustrations show the designer's final model as executed in clay and finally in plaster, and the manufacturer's product in actual use. Designed by Dave Chapman, Arch. '32, Chicago.





Industrial design is that applied art which, built into the products of industry, increases their aesthetic desirability and enhances the proper function. Industrial design should never be practiced and in no way thought of as simply applying surface ornamentation, which is diametrically opposed to the engineering of a product. This may sometimes seem to be true, but the intelligent designer's approach is never so shallow. For this reason it is very desirable that the designer have a knowledge of and some experience with engineering problems, including, if possible, actual shop work, in order that a sympathetic and intelligent approach might be made to the original work of the engineer.

To consider intelligently the design of a product for appearance, its basic engineering functions and limitations must be understood by the designer. He thus begins with a broad grasp of the solutions developed by the engineer and carries on from there. But engineering has not been dismissed from the designer's mind as he attacks his part of the job. As he works, sketching his thoughts on paper, his mind must, consciously and sub-consciously, revert to materials, methods of construction and the techniques limiting the mass production of parts integral to the design. The more able the designer, the more will he keep the engineering aspects of his work in mind, so shaping his work as to be acceptable from an engineering viewpoint when completed.

Nor is this all—the designer, while working, has in mind the merchandising obstacles confronting the product so that when a finished design is presented for consideration the following hindrances should have been digested and solved:

1. The basic engineering requirements—that is, physical dimensions, functions of parts, limits of change, and other like problems.

2. The materials that are to be used, methods of fabricating said material and all possible manner of finishing it.

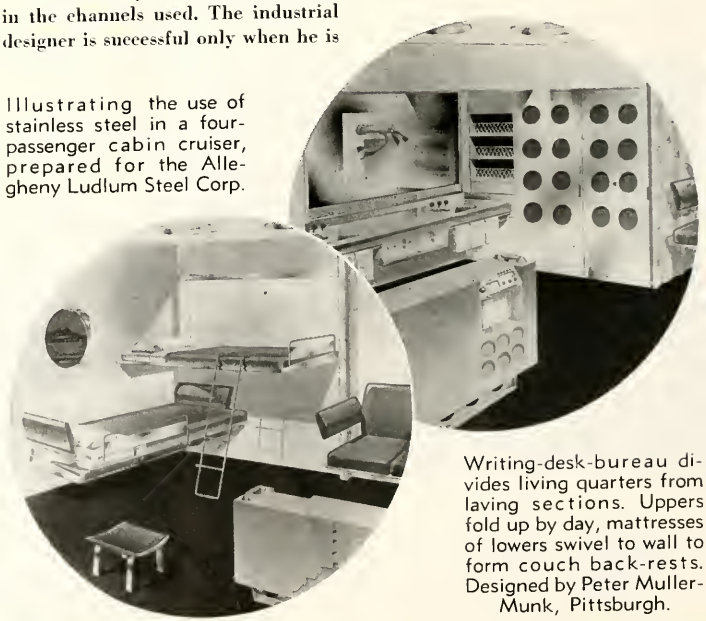
3. The ability of the product to sell in the channels used. The industrial designer is successful only when he is able to merge all these requirements into a pleasing pattern and thus justify his labor.

The need for styling the products of industry is no longer argued—it is an essential factor in building sales and will be increasingly so in the competitive markets just ahead. Other factors being equal, it is natural that functionally styled merchandise will stand above competition. In fact, better looking merchandise can command higher prices and still outsell a shabby competitor.

But the consideration of good design need not be entirely mercenary—in its broad concept it is justified by the dignity and beauty which ought to be inherent in man's environment and which are actually his rights. Nowhere is nature as slovenly in her works as is man in his. A great power has been exquisitely careful about preparing us a pleasant environment and no man has the moral right to despoil the beauty which is the natural right of his fellow-being. This quality should be built into the very structure of our buildings, our bridges, our systems of transportation, and even into the meanest and humblest of the things we use.

See FACE LIFTING on Page 58

Illustrating the use of stainless steel in a four-passenger cabin cruiser, prepared for the Allegheny Ludlum Steel Corp.



Writing-desk-bureau divides living quarters from laving sections. Uppers fold up by day, mattresses of lowers swivel to wall to form couch back-rests. Designed by Peter Muller-Munk, Pittsburgh.

[*Reprinted from the Scientific Monthly, October, 1945, Vol. LXI, Pages 313-316*]

Relative

Heating Requirements

FOR AMERICAN HOMES

BY DR. STEPHEN S. VISHER

THE RECENT SHORTAGE of fuel has increased the interest in fuel requirements of all people whose homes are heated in winter. Millions of families have wondered whether enough fuel could be obtained to carry them through the cold weather.

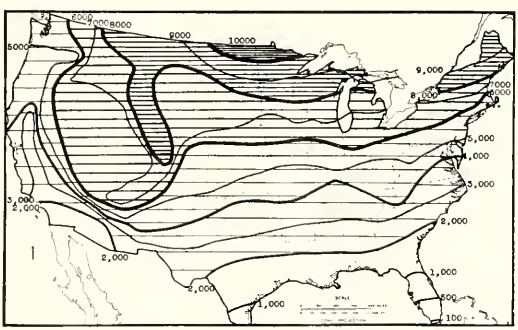
The amount of fuel required for adequate home heating depends, of course, upon several factors beside outdoor temperatures. One of these is the wind. However, since outdoor temperature is a major factor, more adequate information about what temperatures may reasonably be expected is increasingly desired.

Certain data recently released by the U. S. Weather Bureau have permitted the construction of the accompanying original maps. These data were compiled by, or under the direction of J. B. Kincer, long chief of the Climate and Crop Weather Division of the Weather Bureau, in the few years before his recent retirement. They were made available at his special request in the hope that they would become more widely useful.

These data deal with a special sort of temperature description called a "degree-day," which is defined as a day having an average temperature one degree below 65° F. Thus all days with temperature of 65° or higher are ignored in this discussion, on the reasonable assumption that house heating is not needed when the average daily temperature is 65°, for on such days the daytime average temperature normally is somewhat above 70° and the nighttime minimum not much below 60°. On days when the average temperature is 55°, ten degree-day units are registered; a day when the average temperature is zero has 65 degree-day units.

Data on the average number of degree-day units occurring at each of 208 "first order" Weather Bureau Stations by months permitted the construction of Maps 1-5. The variation from year to year in the number of degree-day units is shown, by sections of the country, in the graphs of Figure 1, prepared by Mr. Kincer.

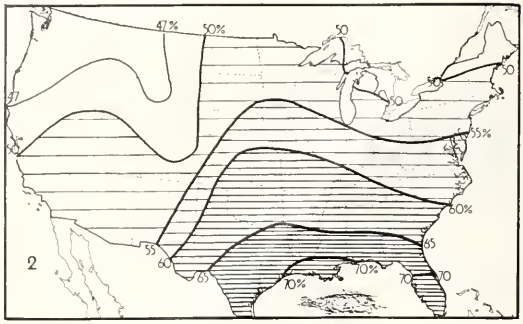
Map 1, of the average annual number of degree-day units, shows that the range is from 100 in extreme southern Florida to 10,000 in northern North Dakota. Thus there is a hundredfold range. In the densely populated part of the country the average number of degree-day units lies mostly between 4,500 and 6,500; for example, it is 4,500 in the District of Columbia, 5,400 in New York City, 5,900 in Boston, 6,800 in Buffalo, 6,200 in Cleveland, 6,300 in Chicago, 4,600 in St. Louis, and 8,000 in Minneapolis. On the Pacific Coast the average is 1,400 in Los Angeles, 3,100 in San Francisco, and 4,900 in Seattle. These wide contrasts imply a vast difference in fuel requirements. For example, Philadelphia has more than twice the degree-day units that Birmingham or Atlanta has, Milwaukee has one-eighth more than Chicago, and Cleveland has one-fourth more than Cincinnati. These percentage variations do not mean quite so great a difference in the fuel supplies needed, however, because of differences in insulation of houses, for example, but they reveal an important range in an appreciable item of the cost of living.



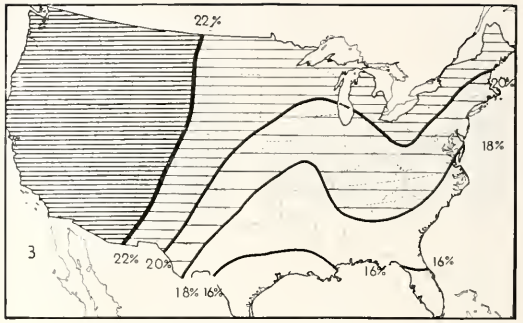
MAP 1. THROUGH THE YEAR

THE AVERAGE ANNUAL NUMBER OF DEGREE-DAY UNITS.

Map 2 shows the fraction of the degree-day units which occur during the winter (December-February). It reveals that winter has about 70 per cent of such units in the Deep South but that the Northwest and extreme Northeast have less than half of their cold weather units in winter. For most of the people of the United States, the three winter months require only slightly more than half of the annual



MAP 2. IN WINTER
PERCENTAGE OF THE TOTAL ANNUAL DEGREE-DAY UNITS.



MAP 3. IN AUTUMN
PERCENTAGE OF THE TOTAL ANNUAL DEGREE-DAY UNITS.

fuel needs. It is interesting to note, for example, that Washington, D. C., Columbus, Ohio, and Chicago are nearly alike in this percentage.

Map 3 shows that autumn is relatively cooler in the West than in the South: that is, in the West the autumn has a larger share of the annual total of degree-day units, between 22 and 24 per cent as compared with about 16 per cent in the South. The northeastern part of the country has about a fourth more, relatively, than the southeastern. The more rapid cooling off of the western third of the country is associated with its higher elevation above sea level and its greater dryness. In the humid East the considerable contrast between North and South, despite similarity of elevation and humidity, is largely associated with the cooling effects of the snowfall of the North. (The South seldom receives snow in the autumn while in the northern part of the North snow is generally in November.)

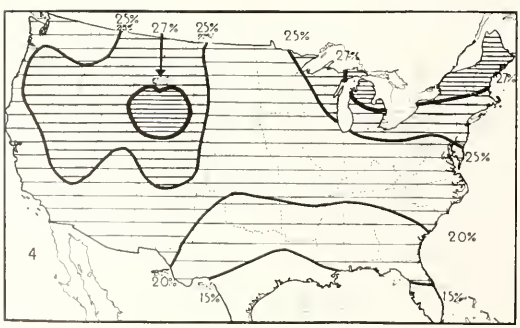
Map 4 shows that the spring quarter year in much of the northern half of the country has about a quarter of the year's degree-day units, but near the Gulf of Mexico the spring has only about one-sixth of the annual total. The South is warmed sooner in spring than the North, partly because the sun is notably higher in the sky at noon and partly because a snow-cover often persists in the North during the early weeks of spring.

Map 5 shows the percentage of the annual number of degree-day units which occur after March 31. In other words, it shows approximately the fraction of the year's fuel which will be needed to maintain comfortable indoor temperatures after April 1. The variation in the more heavily populated parts of the country is less than might be expected; most housekeepers need approximately one-eighth of their house-heating fuel supply after April 1. In Washington, D. C., the percentage is 10, in New York City 12, in Chicago 12, and in Los Angeles and San Francisco also about 12.

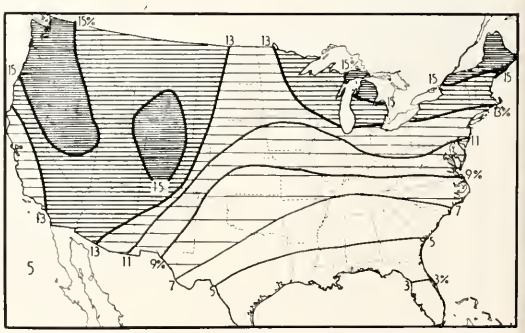
Three additional maps, not here printed, may be briefly described. The fraction of the annual total of degree-day units which occur before November 1 range from about 3 per cent in the Deep South to 7 to 10 per cent in the Northeast and 11 to 13 per cent in the Northwest.

Half of the annual total of degree-day units normally have occurred by January 15 in the Deep South, by January 18 in the most of the western half of the country, and also in the middle South, but not until January 24 in the Northeast. In other words, mid-winter occurs, so far as degree-day units are concerned, on January 13 in Louisiana and New Mexico, on January 15 in Florida, South Carolina, and Arkansas, on January 17 in most of the western states and in Tennessee,

MAP 4. IN SPRING
PERCENTAGE OF THE TOTAL ANNUAL DEGREE-DAY UNITS.



MAP 5. AFTER MARCH 31
PERCENTAGE OF THE TOTAL ANNUAL DEGREE-DAY UNITS.



and on January 20 in Maryland, Ohio, and northern Illinois. The midwinter date comes latest in New England, Michigan, and New Jersey where January 24 marks the accumulation of 50 per cent of the total seasonal degree-day units.

Throughout the southeastern third of the country the summer quarter year normally has no degree-day units. However, about one per cent of the annual total of such units occur along a line extending from New Jersey to Iowa and thence southwest to New Mexico. About 3 per cent of the year's total occurs in summer in New England, Michigan, and North Dakota, and 4 or 5 per cent in the Northwest, from Colorado to Oregon and Washington.

Fuel requirements vary not only from place to place but also from year to year. Although all parts of the United States experience variations in amount of cold, a careful study of the departures from the normal, or average, conditions from 1898 to 1942 shows considerable regional contrast in variability. The variation is least in the Northeast (New England and New York) where only five years of the forty-two studied departed as much as 12 per cent from average, and the greatest departure was only 14 per cent. The South Atlantic States, by contrast, had a greater than 15 per cent departure from average or normal; two seasons were more than 30 per cent colder than normal, and 1930-1931 was 39 per cent warmer than normal. Of the 10 regions of the United States studied by J. B. Kincer, the average percentage variation from normal was approximately as follows (estimated from his graphs by years): Northeast 10.0; East North-central States 11.8; Northern Interior (North Dakota and adjacent states) 12.3; Central Interior (Kansas, etc.) 12.3; Rocky Mountain States 13.0; North Pacific States 15.3; California 23.4; Middle Atlantic States 12.9; South Atlantic States 28.6; South-central States 22.1. These data show that the average range along the southern border of the country is more than twice as great as along the northern border.

The extreme variation experienced in these 42 years was somewhat more than twice as great as the average variation. It was least in the Northeast (26 per cent from normal, 14 above, 12 below); it was 30 per cent in the belt that extends from New Jersey to Kansas and from Kentucky to the Great Lakes; on the Pacific Coast the extreme range at the North averaged 41 per cent, while in California it averaged 60 per cent. The increase in range southward from Virginia and Oklahoma is sharp, an extreme range of 60 per cent occurring in South Carolina and central Texas and one of more than 70 per cent near the Gulf Coast.

Thus, although the winters of the North average much colder than those of the South, a long-time average reveals that the cold of the North is more regular and predictable than that of the South.

A climatic problem of widespread interest—how our climate is changing—is illuminated by the Kincer data on the departures from the normal of the averages of annual degree-day units. Kincer's studies reveal that the last half of the period 1898-1942 has been warmer than the first half in all regions of the United States. The warming has been greatest in California; next

See HEATING on Page 58



FIG. 1. DEPARTURE FROM NORMAL OF DEGREE-DAY UNITS.
BAR GRAPHS BY J. B. KINCER OF THE U. S. WEATHER BUREAU, SHOWING PERCENTAGE DEVIATIONS, 1898-1942.



The figurine at the right is a 17th century sculptor's allegorical interpretation of the functions of the human body. The model is cut from a single piece of ivory and is here displayed before the title page of an early anatomical study published in 1639.

A NEGLECTED CHAPTER

in The History *of* Anatomical Illustration *and* Instruction



BY DR. ARNO B. LUCKHARDT

JUST AS WE EXPECT an automobile mechanic to be conversant with the parts and functions of an internal combustion engine, so we have a right to demand that the physician has a technical knowledge of the machinery of our body and its normal or pathological physiology.

Anatomic illustration and instruction is an aspect of historical medicine which was in part even unfamiliar to the late Dr. Fielding Garrison whose "Epitome of the History of Medicine"—a really monumental work in spite of its modest title—does not contain even a paragraph on certain parts of my subject. In Mortimer Frank's translation of Choulant's "History of Anatomic Illustration," this same Dr. Garrison wrote a chapter on the use of plastic material in medicine restricted to ancient marble and metallic votives. However, his article makes no mention of the figurines which are eventually the subject matter of this article and of the illustrations herein contained. These figurines were prepared and used during the 17th-18th and the early part of the 19th centuries for the purpose of teaching anatomy and midwifery—obstetries.

In outlining the sequence of events which eventually lead to the production of the manikins or figurines, the

writer hopes to succeed in avoiding gruesome anatomical situations which might be revolting. In outlining the evolution of the subject matter certain facts must be presented for purposes of historical continuity; but the emphasis will be on the artistry of our medical forebearers and the people—artists—who labored with them.

Aristotle's description of the isolated organs of lower animals was faulty to ridiculous in many instances; and the famous Galen performed his dissections, partly on dogs, but usually on swine. Galen did make a rather difficult trip from Rome to Alexandria to view a human skeleton, but had no knowledge of the form and relationship of the internal organs of man. In the Rome of his day human dissection was not permitted. His animal experimentation was likewise restricted to dogs, apes, and swine, as the result of which he made many fundamental discoveries and some errors.

The physicians who followed Galen attributed his work to human dissection and his writings, necessarily devoid of illustrations, constituted as sacrosanct a volume on medicine as is the Bible today to a Fundamentalist. For some thirteen centuries no one but a medical heretic would doubt his "ex cathedra" statements. Subsequently, when anatomists found the human anatomy different from Galen's descriptions, it was interpreted as meaning that man had changed since the time of Galen. Thus evoking the first known theory of evolution without questioning the fallibility of this great man.

With the decadence of the Roman Empire, Galen's works and those of other Greek physicians were translated into Arabic. Arabs by the tenets of their religion were not permitted to desecrate the human body by dissection. In the process of translation, the original text was paraphrased and garbled, and, when in the 11th century the Benedictine monks retranslated the Arabic texts into Latin, further garbling of the Arabic text was inevitable—no two translations being the same.

In the 14th century an annual judicial and public dissection of a condemned criminal was permitted in Venice. About 1316 Raymund de Luzzi (Mondino) was the first to teach from a cadaver. His instruction consisted of four discourses coupled with dissections on the human body before the student body. If these dissections were inadequate and most perfunctory the trend was in the right direction, in spite of a blind leaning to the dicta of Galen whose descriptions were read by the professor whilst a prosector did the actual dissection. The written word of Galen held precedence over the actual findings of the specimen immediately before the audience.

In the 16th century there lived a group of medical (philological) humanists such as Guinther of Audernach and the Catholic priest Thomas Linacre of England. These men were dissatisfied with the medical texts which had been garbled in turn by the Arabian physicians and the Benedictine monks. The humanists retranslated the original Galen texts and others, and were impressed by the scientific method employed by Galen. As a result there followed the method of direct investigation.

A pupil of one of these men was Andreas Vesalius, an indefatigable dissector of the human body and now considered the father of human anatomy. His illustrations from actual human dissections were published in 1543 under the title "Fabrica Corporis Humani."

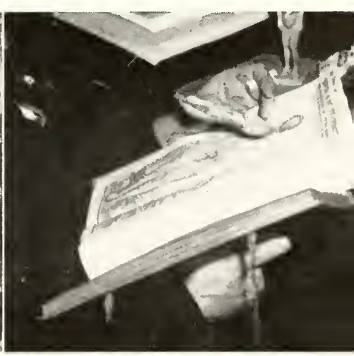
With the advent of printing, wood block figures, and real investigation on the cadaver, modern anatomy began. There were, however, two difficulties:

1. The anatomist was not likely to be an artist who could portray accurately what he saw in his dissections. Bartholomew Eustachius was an outstanding exception. He could both dissect and make accurate copper plates of his dissections.

2. The employed artist, on the other hand, was primarily concerned with external form and as a dissector was not interested in nor could he dissect carefully the internal organs. Leonardo da Vinci was an exceptional genius but even he worked in conjunction with a surgeon, who, incidently, died before the joint projected collaborative work was completed. As a result, collaboration







LEFT: The portion of a B. Eustachius print here visible indicates his method of anatomical illustration.

CENTER: Part of a plate from the set prepared by the Dutch anatomist, Govvard Bidloo, and later claimed by Cowper, compared with a manikin.

RIGHT: Like an intricate paper doll are the many-layered illustrations superimposed on one another to suggest body parts in this book designed by Leonard Thurneyyser and published in 1576.



Dr. Arno B. Luckhardt, the author, whose collection of ten manikins is the only one in the United States, and one of the few of its kind in the world.

of the artist and the anatomist offered the logical solution when the anatomist was not also somewhat of an artist.

Bartholomew Eustachius was both an artist and an anatomist as well. His volume of anatomical plates completed in 1563, although not published until 1714, is his handiwork alone. Not only did he prepare the illustrative dissections but he also made the copper engravings. The engravings are hard and stiff from an artistic point of view, but they are more accurate than the plates in the earlier Vesalius' "Fabrica Corporis Humani" which were prepared by van Calcar, a pupil of Titian. The Vesalius plates are more pleasing to the eye but betray definite artistic tendencies absent in the Eustachian prints.

The most beautiful and accurate anatomical plates ever produced by an artist from specimens prepared by the Dutch anatomist, Govvard Bidloo, and published in folio during the last quarter of the 17th century. These plates represent the most beautiful examples of copper etchings of an anatomical nature. The illustrations appealed so strongly to a distinguished English anatomist, William Cowper, by name, that he acquired 177 sets of the illustrations, wrote an English text for them and published them in England under his own name in 1698 after adding a few inconsequential illustrations of his own. Cowper simply pasted his name over that of Bidloo's on the title page. The theft was soon detected. Cowper was exposed by the illustrious Haller who wrote to the effect that "it is to be grieved (dolendum est) that so great a man (Cowper) lent himself to such seduction."

But even the finest examples of collaboration of artist and anatomist failed to represent the body structures in three dimensions, thus failing to represent the organs in their relationship to one another. Endeavoring to overcome this lack, the idea of constructing illustrations by a method of superimposed plates occurred independently to several different, widely-separated anatomists and teachers. These plates were designed to fold back like the leaves of a book revealing successive occurrence of the various organs in the body.

One of the earliest of these was produced in 1576 by Thurneyyser. The best example was that designed by J. Remmelin in 1607, who believed that the form was his own invention. It is to marvel at the ingenuity and patience of the artist when one examines these folding superimposed figured flaps. Hours must have been consumed in deciding how best to illustrate and construct these intricate anatomical charts.

But even this form of anatomical representation was not deemed satisfactory to some anatomists and surgeons. They resorted to plastic materials to illustrate contours and relationships in three-dimensional space. To overcome these difficulties, they constructed manikins or little men and women. The surviving manikins, carved most commonly in ivory and containing movable parts, are very rare. The only collection of them in this country, consisting of ten figures, is owned by the author, who uses five to illustrate this article.

Briefly, the manikin is a model of the human body, containing many of its parts which can be removed in demonstrating its anatomy or in practicing certain manipulations, as in obstetrics. For the most part the figurines are carved in ivory, wood, or marble, and are from 15 to 18 centimeters in length. As a rule the manikin is constructed so that one or both arms are movable at the shoulder joint about pegs. The chest and abdominal wall can be removed as one piece, revealing the various thoracic (chest) and abdominal viscera, either cut out of the block or appearing therein as movable structures. The latter construction led to loss of the parts.

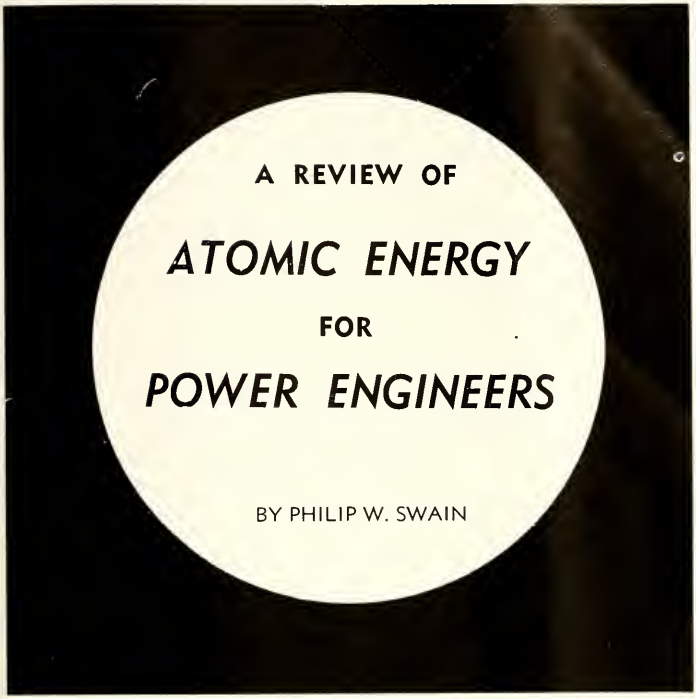
A common rule seems to have been established in the construction of the male and the female manikins, for in most examples the female abdomen contains a pregnant uterus with a fetus in a "See No Evil" position; the male abdomen, on the other hand, usually encloses a large urinary bladder which is often winged.

Only one of the models pictured merits a special description, since it was constructed for purely artistic reasons. This will be obvious, for the organ systems are represented allegorically. For example, the respiratory system is represented by two diminutive carved men pumping up a pair of bellows (the lungs). The circulatory system is indicated by a figure pounding an anvil with a sledge hammer (pulse). A vat containing fermenting

See NEGLECTED on Page 60

One of the female manikins showing the chest and abdominal wall removed along with the abdominal viscera, the womb laid open and the fetus exhibited.





ALMOST NOTHING that is fundamental, important and new about atomic energy has been made public since the famous Smyth report. This paper, like all the rest, merely restates what Smyth revealed or what was known before Smyth. To this is added conclusions an engineer can easily draw from such information. The triple excuse for this rehashing of atomic facts is the wide interest in atomic energy, its importance and the fact that many engineers have not yet studied.

Atom Structure

The 92 natural elements range from hydrogen (No 1) to uranium (No 92). Like our solar system, each atom has its central sun, the nucleus, about which the planetary electrons revolve in elliptical orbits. Just as the gravitational pull of the sun keeps the earth circling about it, so the positively charged nucleus attracts the negatively charged electrons, thereby holding them in their orbits.

The nucleus contains only protons and neutrons, each of which has a mass very close to 1 atomic unit. By definition, this atomic unit of mass is exactly 1/16 the mass of the oxygen atom. The neutron is electrically inert, while the proton has a charge of +1, measured in atomic units.

The electron has a charge of —1 and a mass 1/1850. For our practical purposes the electron's mass is zero. Thus:

	Mass	Charge
Proton	1	+1
Neutron	1	0
Electron	0	—1

In no case do all the electrons constitute more than 1/18 part of one per cent of an atom's mass. Practically speaking, the entire mass of the atom is in the nucleus.

To find atomic weight to the nearest whole number, merely count the particles (protons plus neutrons) in the nucleus. Since the negative electrons must electrically balance the positive nucleus, the number of electrons in orbits must equal the number of protons in the nucleus. This number (protons or electrons) is also the number given to the atom itself in the periodic table.

Therefore hydrogen, element No. 1, must have 1 proton in the nucleus and 1 electron planet. The hydrogen nucleus has no neutron, so its atomic weight is 1.

Being element No. 2, helium must have 2 protons and 2 electrons. It also has 2 neutrons, so its atomic weight is 4.

It should be mentioned here that ordinary chemical reactions are concerned only with the electronics, whereas nuclear reactions are concerned only with the nucleus.

Element No. 6 is carbon. Because its atomic weight is 12 we know that its 6 protons are associated with 6 neutrons. Oxygen, element No. 8, has 8 protons, 8 neutrons, and an atomic weight of 16. Beyond hydrogen in the periodic table all elements have at least 1 neutron per proton and many (particularly the very heavy elements) have more.

Isotopes

Most elements have several forms called isotopes. The only difference between the isotopes is in the number of neutrons, since both protons and electrons must equal the atomic number. With the same number of electrons all the isotopes of the same element must act alike chemically, although they differ in weight.

A rare isotope of hydrogen, called heavy hydrogen or deuterium, adds a neutron to the normal hydrogen nucleus, thus raising its atomic weight to 2. Deuterium combines with oxygen to make D_2O or "heavy water" having a molecular weight of $4 + 16 = 20$, whereas that of ordinary water is $2 + 16 = 18$.

Uranium

Element No. 92, uranium, heaviest natural element, has two important isotopes, uranium 238 and uranium 235, together constituting almost 100% of natural uranium. The isotope U238 is 99.3% and U235 is 0.7%. Here the numbers 238 and 235 are the approximate atomic weights—also the exact number of particles (protons plus neutrons) in the nucleus. Since the protons in both cases must number 92, the neutrons are 146 and 143 respectively.

Atom Splitting

"Atom splitting" means splitting the nucleus. The correct term is "nuclear

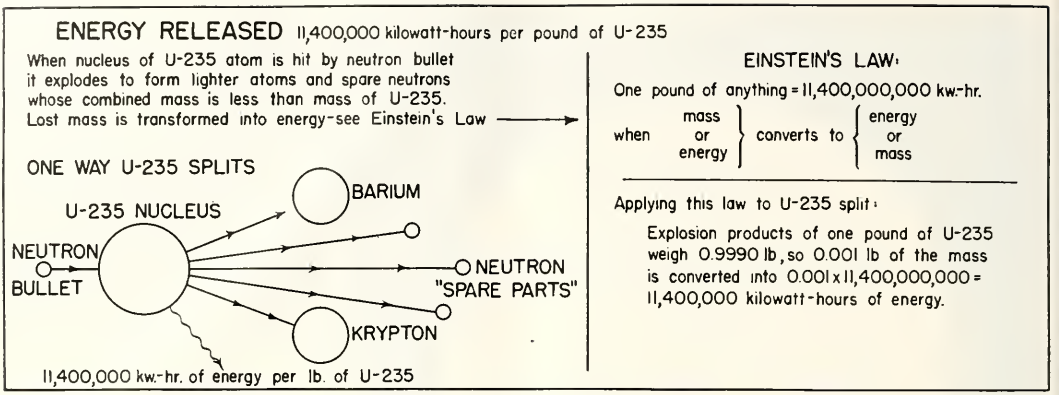


Figure 1. See note on page 60.

fission". When nuclei are split the electrons take care of themselves. Each new nucleus will automatically pick up as many electron planets as it has protons.

A few nuclei of naturally radioactive elements, such as radium, split by themselves at an unalterable rate. Generally, however, the splitting of a nucleus requires a blow from some other particle. Neutrons are the best bullets for atom splitting because they have no electric charge and are therefore not repelled by the positively charged nucleus.

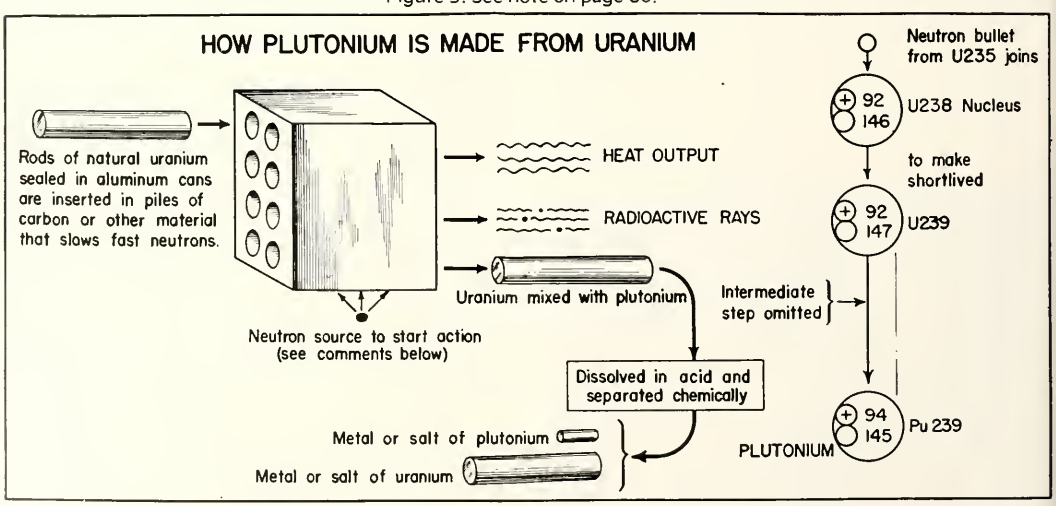
Generally the neutron must move at high speed to split an atom. U235 is an exception. Either a light or a heavy blow by a neutron will split U235 into two lighter nuclei and release much energy. If circumstances are right, a self propagating or chain reaction may be set up in a mass of concentrated U235 or in U235 mixed with U238 or other substances. The atomic bomb uses a fast-neutron chain. Commercial atomic piles will use neutrons moving at slow or intermediate speeds.

Consider first a fast-neutron chain reaction in a substantial mass of pure U235. A neutron shot in from the outside splits one nucleus into two light nuclei plus 1 to 3 high-velocity neutrons. These neutrons hit other U235 nuclei, which in turn split, releasing more neutrons. Thus the splitting sweeps through the U235 mass with explosive speed and power, as in an atomic bomb.

Now it is very difficult to hit a nucleus with a neutron because the atom is mostly empty space with a tiny nucleus in the center. On the average a fast neutron will pass freely through millions of atoms before hitting any nucleus. To maintain a fast chain the mass must be so large that for each thousand atoms exploded at least 1000 released neutrons will succeed in splitting new atoms. If the U235 mass is too small, the chain fails because too many neutrons escape without hitting nuclei.

Any mass smaller than this critical mass of U235 cannot be made to "explode". On the other hand, a mass larger than the critical cannot be prevented from "exploding", since even cosmic rays will start the chain re-

Figure 3. See note on page 60.



action. Thus, says Smyth, a bomb must contain more than the critical mass of U235 (or plutonium) divided into two or more pieces, each of less than the critical mass. At the desired moment of "explosion" these must be brought together rapidly to form a mass greater than the critical.

The critical mass of pure U235 for a bomb, according to Smyth, is more than 2 kg and less than 100 kg. Nothing more specific has been made public.

Slow-Neutron Chain

This explosive chain reaction with fast neutrons is clearly not suitable for commercial heat or power generation. Such applications must use another remarkable property of U235, the fact that its nucleus can be split equally well by a fast blow or by the very light tap of a slow neutron, one moving no faster than a gas molecule at room temperature.

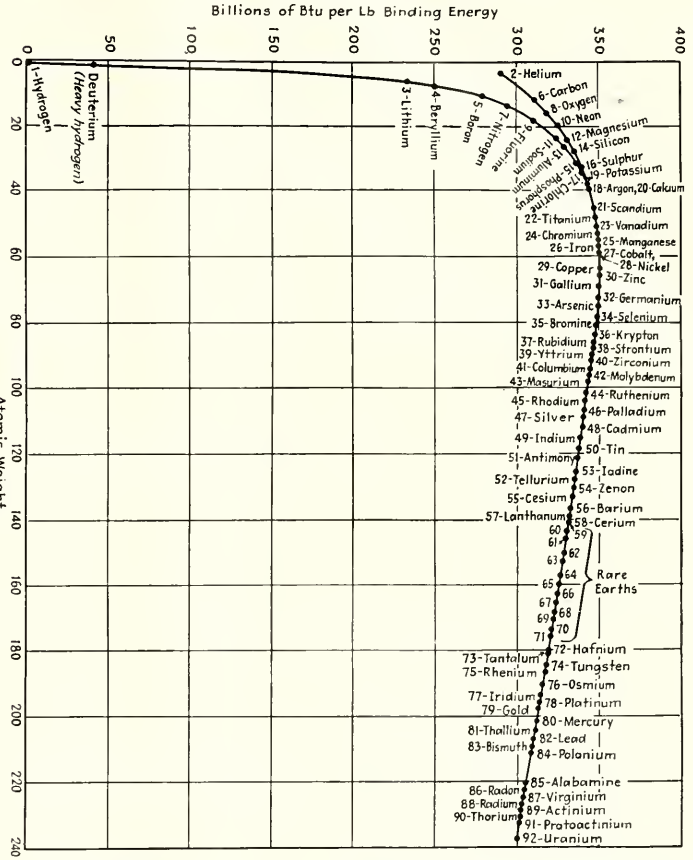
The slow neutrons, in fact, have one great advantage, they greatly reduce the critical mass required for a chain reaction. Where a fast neutron would make a near miss, the slow neutron passing close by is sucked into the nucleus by some force that operates strongly at minute distances.

At Hanford, Washington, rods of natural uranium are inserted in a large lattice or "pile" of carbon. The carbon moderator slows down the neutrons, so greatly increasing their effectiveness that a chain reaction can be maintained in a pile using natural uranium containing no more than 0.7% of U235. However, the carbon-natural-uranium pile must be very large to operate. Much smaller piles will support a chain reaction if the uranium is enriched to a higher percentage of U235.

Such uranium-carbon piles are built slightly larger than the critical size for the given concentration of uranium, and are then "throttled" to a balanced-chain operation by sliding in cadmium strips to absorb any excess of neutron supply over neutron requirements. The slow-neutron pile has a slight lag in response and some inherent stability, so automatic control is possible. If the slow-chain reaction should get out of control—run wild—the resulting explosion would resemble a boiler explosion rather than an atomic bomb explosion.

A fast-neutron pile, without carbon or other moderator, would be more difficult to control, as a heat source, even if one could afford the high U235 concentrations required for a fast-neutron chain reaction in a pile of reasonable size.

Figure 2. See note on page 60.



Energy Values

Whether the chain be fast or slow, the fission of one pound of U235 releases 39 billion B.T.U.—the equivalent of 1400 tons of good coal. This energy results from the disappearance of about 1/10% of the mass of the U235.

Decades ago Einstein stated that, to some degree, mass is convertable into energy, and that the disappearance of 1 gram of mass must yield energy, in ergs, equal to the velocity of light squared.

In the usual English engineering units, one pound of mass therefore equals:

11.4 billion kw. hr.
39 trillion B.T.U.
30 quadrillion ft. lb.

To determine the actual energy given off or absorbed per pound in any nuclear transformation, multiply the foregoing constants by the decrease or increase in mass. When U235 is split the fragments weigh 0.999 lb. Weight loss is .001, so the energy released per pound is

11.4 million kw. hr.
39 billion B.T.U.
30 trillion ft. lb.

Since no neutrons or protons are created or destroyed in the fission of U235, one may ask how the weight can possibly change. The answer is that

the protons and neutrons bunched in the nucleus do not weigh exactly the sum of their separate weights.

This becomes clear when the masses of protons and neutrons and nuclei are given precise values rather than the round numbers used so far in this paper.

Here are precise values from Smyth:

proton mass 1.00758
neutron mass 1.00893

Now consider one helium nucleus containing 2 protons and 2 neutrons. Figuring from the individual proton and neutron weights, the helium nucleus should weigh 4.03302. Actual weight is 4.00280, a "binding energy" shrinkage of .0302. This is .0075 lb. out of every pound. We may conclude that the formation of 1 lb. of helium from neutrons and protons (hydrogen nuclei) yields .0075 x 39 trillion B.T.U. = 290 billion B.T.U.

Actually the heat of the sun comes from this reaction, nearly 8 times as potent as U235 fission, but impracticable on the earth because of our temperature limitations.

Fig. 3 shows the "binding energy" in B.T.U. per pound, of all the natural elements, plotted against their atomic weights. Here binding energy is the energy released when the nucleus is formed from protons or neutrons. Hydrogen, having only a single particle in the nucleus, has no binding energy. Note that helium has 290 billion B.T.U. per lb., the energy released by the production of 1 lb. of helium from hydrogen. To release energy, one moves from either end of the chart toward the center—that is builds up the light atoms or breaks down the heavy atoms.

The splitting of uranium gives several neutrons and two different atoms averaging somewhat less than half the weight of U235. Taking the round number 115 as the approximate average weight of the lighter atoms produced, we see from the chart that the split releases 339 — 300 = 39 billion B.T.U. per lb.

Of the natural elements only uranium and possibly thorium now appear promising as chain-reaction energy sources. Beyond uranium the artificial element plutonium (No. 94) is a present substitute for U235. Other still higher numbered synthetic elements may prove useful.

The piles at Hanford are run solely to manufacture plutonium for bombs. All heat generated is wasted to the Columbia River in the cooling water circulated through the piles. In the pile slow neutrons, retarded by the carbon moderator, maintain the chain reaction in the U235. At the same time other neutrons of suitable speed strike the much more abundant U238 nuceli, converting them into neptunium which soon turns to plutonium.

After this pile has operated for a while the chain reaction slows down because the accumulating fission products (middle-weight atoms), capture neutrons unproductively and leave less for the U235 chain. The uranium rods must then be removed and chemically treated to extract these impurities as well as the plutonium.

This very difficult operation would be equally necessary with a commercial power pile, but there the plutonium could later be returned to the pile along with the purified natural uranium. As an adequate substitute for U235, the plutonium would in effect, extend the supply of U235.

Counting only the energy in the U235, one pound of natural uranium containing 1/140 lb. of U235 is equivalent to 10 tons of good coal. If one assumes a prewar uranium price of $2.00 per pound it might seem that uranium fuel could compete with coal costing 20 cents per ton. The solution is not that easy. It may be years before this theoretical dollar advantage of uranium over coal can be made actual because of the great cost of purifying the uranium to the required degree and even more, of conducting the chemical purification of the used uranium by remote control to avoid human exposure to the deadly radiation. However, it is not implied that these now costly operations may not some day be made economical by engineering ingenuity.

Despite the immense cost of concentrating the U235 by the gaseous diffusion and other physical separation processes, such processes may have a place in commercial atomic-heat applications to permit smaller and more efficient piles using U235 concentrations well above the natural 0.7%.

No data are yet available for making even the roughest economic predictions. Present costs, based on pioneer wartime operations, are known to be high. They probably bear little relation to the costs that could be achieved by years of dollar-wise engineering.

The above-mentioned difficulties of pile operation, and the need for a very large pile if a chain reaction is to be maintained without excessive cost for enrichment in U235, indicates that large plants will become economical before small. These may be central stations of 100,000 kw and up, and their B.T.U. equivalent in central heating and process plants.

Another possible use is for ship propulsion, particularly for long voyages, and for war ships. The minimum of 50 tons of shielding required against radio-activity eliminates atomic power for automobiles and small airplanes and makes it doubtful for locomotives.

Unfortunately, also, the large pile is automatically a producer of plutonium, the world's most powerful explosive. While this cannot explode unless available in one spot in the concentrated form and in critical quantity, any large atomic power plant must be viewed as a producer of plutonium that might be diverted for use in bombs. The whole matter of national and international atomic controls will therefore be involved, directly or indirectly, in the operation of such plants.

If and when uranium can undercut coal as a power-plant fuel, the resulting savings will be economically important, but consumers should not expect any revolutionary reduction in the delivered price of power. There is no good reason to expect any reduction in fixed charges or in operating supervision and labor. Therefore, on the basis of today's costs, the saving per kilowatt won't exceed 3 mils minus the cost of the uranium used per kilowatt hour.

At some unknown future time, near or distant, these rather bearish economic predictions for atomic power may be overthrown by some revolu-

See ENERGY on Page 58



Industrial Research Progress at Armour Research Foundation of Illinois Institute of Technology 1944-45[1]

As of August 31, 1945, Armour Research Foundation completed its ninth year of research and experimental engineering service to industry, government agencies, and the public. In spite of manpower and building restrictions imposed by the war, industrial research appropriations for the year just concluded increased to $1,991,346, compared with $1,668,845 for the prior fiscal period and with $30,000 in the first year of operation. Thus is maintained an unbroken record of increasing annual appropriations over a period of nine years (Fig. 1) to testify to the effectiveness of the Armour Plan in the solution of many technical problems for industry.

As has been the case through all of the war years, every effort of the Foundation has been directed toward cooperating as fully as possible with government agencies and industrial sponsors on projects having a direct bearing upon the national effort. Consequently, a considerable number of prospective projects not related to the war situation could not be accepted and, at the same time, work on several previously active investigations remained suspended during the year with the excellent cooperation of certain sponsors.

While the cessation of hostilities will eventually release large numbers of technically trained men and women from military service, it is fairly certain that the needs of industry in this respect will not be met and that several years must elapse before the required number of properly trained individuals have been graduated by our universities and colleges. The seriousness of this situation is very great for, coupled with the lack of high-caliber scientific people, there has been an increased demand for their services, brought about by the greatly intensified government and industrial research programs for purely war purposes. Not only industry in general, but the public at large, is research-conscious as never before.

Inevitably then, there have been and are continuing to be established a considerable number of new research organizations. This is as it should be, and Armour Research Foundation has been able to offer counsel to many of these new institutions to the end that they might profit by the Foundation's experience. It is inevitable also, as in every great surge of activity, that some of these newer organizations will fail to achieve the expected measure of success for one reason or another.

It seems appropriate, therefore, to restate the underlying philosophy which should—one could say *must*—motivate all industrial research activity: that of undertaking research only if it is expected to result ultimately in genuine public benefit. While the immediate objective may be to improve products or processes, reduce manufacturing costs, or develop new uses for existing products, the end point is the same in all cases if the investigation is successful, in that the consuming group reaps the benefits. The Foundation does not accept projects submitted to it in which this requirement is not evident.

[1] From the Ninth Annual Report by Jesse E. Hobson, Director, to the Board of Trustees of Armour Research Foundation of Illinois Institute of Technology, a non-profit industrial research organization located at Technology Center, Chicago 16.

It may be, too, that many manufacturers and businessmen, not too familiar with the vagaries of research, have been somewhat oversold on its potentialities by the momentous events of the past few years. To these people a word of caution may be in order. Research is not simply a matter of pouring the factors of a problem into a hopper, pressing a button, and having the solution, neatly packaged, pop out at the other end. On the contrary, effective research — always bearing in mind the benefit to the public—is the deliberate process of planning a program much as one would outline his insurance needs, placing this program in competent hands, whether it be in the manufacturer's own laboratory, a university, an independent foundation, or a commercial testing laboratory, and then cooperating fully with such research unit until the problem is solved or it becomes apparent that no solution exists. In many cases this procedure will require an unbelievable amount of patience.

While most manufacturers are well aware of the fact that industrial research can be of immeasurable advantage to them, many are not too certain as to which of their problems will be most fruitful of results if attacked or under what conditions the attack should be launched. As a preliminary measure in projects in which this situation exists, Armour Research Foundation greatly intensifies its customary initial survey of the sponsor's manufacturing process and its products to the end that a completely defined and comprehensive program of research may be recommended. It is anticipated that the Foundation's efforts in this direction will expand considerably with the reconversion of industry to peacetime production.

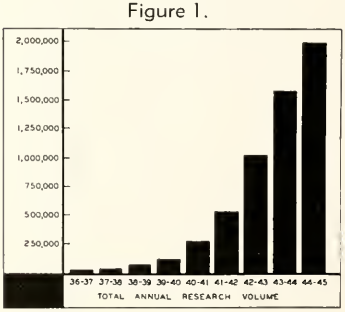
During the past fiscal year 141 major research projects have been in operation, including 58 new investigations. Since the Eighth Annual Report *(1)*, 791 additional short-term studies have been conducted. To date, the Foundation has undertaken 320 long-term research programs, together with 6,295 minor studies and special tests, serving a total of 1,834 large and small manufacturers, associations, government agencies, and individuals. One hundred and ten long-term industrial research projects are in operation at present.

Under the Armour Plan for Industrial Research, each accepted project becomes the direct responsibility of the Foundation itself and not of any individual or section. Because the solution of a given industrial problem usually involves the consideration of factors not immediately apparent, the resources of the Foundation's various divisions are completely coordinated and geared for cooperative effort whereby all their individual functions can be brought to bear at once, if necessary, toward the early solution of the entire problem. Contracts reserve for the sponsor all patent rights and provide for completion of the investigation and treatment of findings in strict confidence.

As part of the Foundation's program for the advancement of individual staff members, a particularly useful series of weekly seminars has been inaugurated for the discussion of important developments in the fields of metallurgy, physics, and the structure and behavior of solids.

The year just closed has been marked by a number of organizational changes under new directorship, designed to weld together a still more efficient operating staff. On January 1 there was activated a Division of Electrical Engineering to which were transferred certain electronic activities formerly supervised by the Mechanical Engineering Division. In April a Division of Research Services was formalized under the supervision of a chairman. This new unit assumed responsibility for many of the routine services required for internal operation, such as drafting, machine shop and carpenter shop activities, photographic service, and maintenance. This division also includes the product development group established to serve industrial sponsors.

Figure 1.



The work in mechanics of solids and mechanical engineering was divided on May 1 with the formation of a new Division of Fluid Mechanics and Thermodynamics. Staff and facilities in mechanics of solids remain in the original division.

Within the Chemistry Division has been organized a new analytical section comprising activities in wet chemistry, x-ray diffraction, spectroscopy, microscopy, and physical testing. This group, in addition to functioning as a service to the Foundation, is also prepared to offer to industry a most complete analytical service in which the various laboratories supplement each other to provide qualitative and quantitative analyses of a magnitude hitherto unobtainable in commercial organizations.

The Foundation now functions through eight major divisions as follows: Physics, Metallurgy and Minerals, Chemistry and Chemical Engineering, Mechanics of Solids, Electrical Engineering, Engine Research, Fluid Mechanics and Thermodynamics, and Research Services. Its total staff at the end of the fiscal year numbered 322.

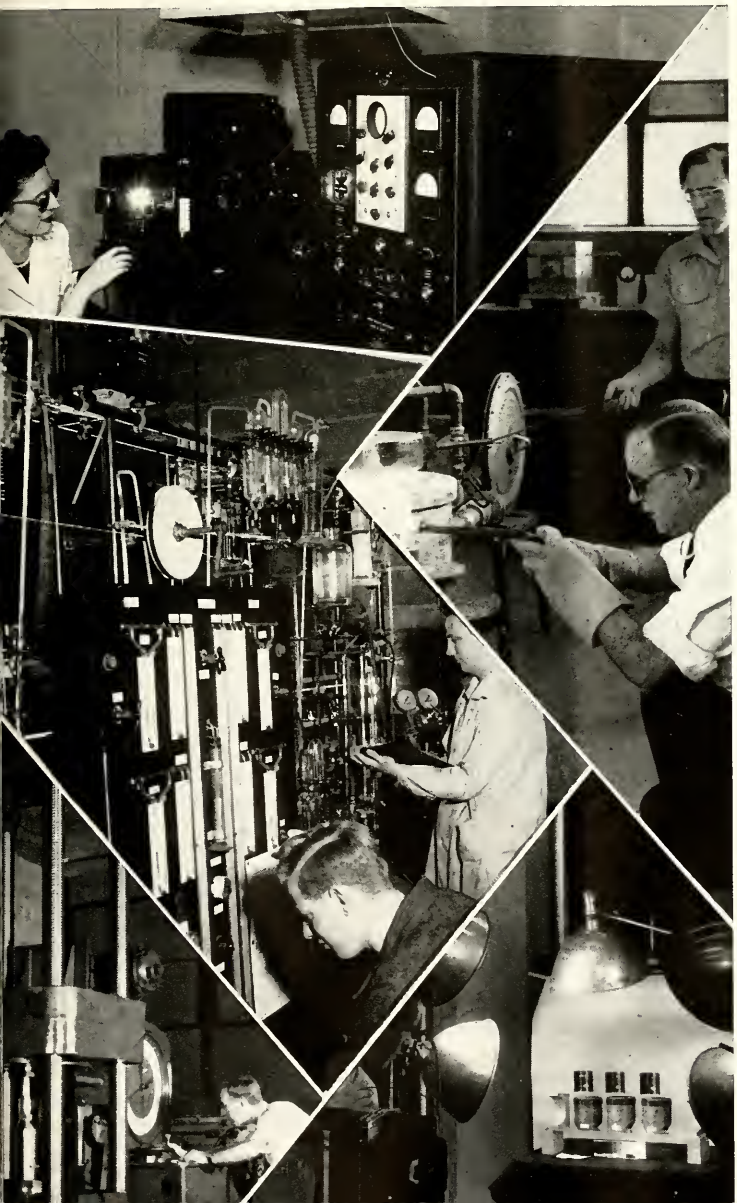
New Facilities

In July ground was broken for the construction of the third unit of the new Engineering Research Building *(1)* with completion planned for next February. This unit, to cost $140,000, will contain over 16,000 sq. ft. at street level and a balcony area of 4,800 sq. ft. Being constructed as a contiguous portion of the two sections completed last year, the new addition maintains the same 20-ft. ceiling height and entirely encompasses the Ceramic Kiln Building of 2,000 sq. ft. built earlier because of need, but so situated as to occupy its proper place in the Engineering Research Building expansion.

According to present plans the ad-

dition now under construction will provide urgently needed space for expansion of activities in high pressure research, electrical engineering, drafting, wire recorder research, product development, electronics, fluids and solids research, and chemical engineering. Facilities will also be provided for the return to the Foundation of the Army Ordnance Department precision gage laboratory in an expanded form, with which will be consolidated the present facilities of two instrument shops. As a temporary measure, approximately 7,000 sq. ft. in the new unit will be used by Illinois Institute of Technology for library facilities.

This year also witnessed the completion of arrangements whereby all research activities of the twenty-year-old Lithographic Technical Foundation, an industrial association of lithographing companies and suppliers, were transferred to Armour Research Foundation. Pending erection of a suitable building on the campus, the lithographic research activities have been established in Glessner House, located at the southwest corner of 18th St. and Prairie Avenue, where 10,000 sq. ft. of area are available. In addition to a reception room, conference rooms, and an unusually complete technical library, there are being constructed for research investigations laboratories for physical and organic chemistry and a hood room, these units to be equipped with a variety of apparatus including an inkometer, humidity cabinet, ink mill, plate whirlers, and other equipment specially designed for lithographic studies. Regular production units will include a plate-making laboratory, a dark room, and a pressroom, the latter to have as its major equipment a 19 x 25-inch Harris offset press and a graining machine. It is expected that a considerable amount of additional equipment will be required as the various phases of lithographic research are taken up. Glessner House also has classroom facilities available for certain types of educational courses and employee training activities for advancing lithography.



The research agreement executed by Lithographic Technical Foundation and Armour Research Foundation provides for working cooperation between the two organizations on projects determined by LTF. It also provides for research guidance, research work and service for individual lithographers and suppliers who contract for such work through separate facilities and personnel at A. R. F.

On the campus the Chemistry Division has expanded its biochemical facilities in the Main Building to occupy one-half of the laboratory formerly devoted to inorganic investigations. An additional laboratory for research on tanning processes and materials has also been set up. The organic group, due to increasing space requirements, has acquired the remaining half of the former inorganic laboratory and, in addition, has been provided with a new hood room. Photomicrography and chemical mi-

croscopy laboratories, as units of the newly created analytical section, have temporary quarters.

The Physics Division, also in the Main Building, has several new laboratories, one of which is equipped with a number of different vibration measuring instruments and a special apparatus for determining the dynamic constants of vibration isolation materials such as rubber, cork, felt, and special vibration mountings. A console type electron microscope has been installed for the study of problems requiring a resolving power beyond the range of the best light microscopes. A resolving power down to approximately 100 A. can be obtained and useful magnifications up to 100,000 times are possible. This laboratory also functions as a unit in the new analytical section. A second complete x-ray diffraction unit, a briquetting press, a microphotometer, and a large amount of auxiliary equipment, such as bridges, recorders, meters, cameras, etc., acquired during the year, have permitted considerable expansion of activities in x-ray work, spectroscopy, optics, acoustics, and electronics. A new laboratory for work in illumination engineering is now in use for studies in all types of lighting equipment, as well as the measurements of luminous flux, intensity, color temperature, and candle power.

A considerable amount of reorganization of facilities in the State Street Building has taken place due to the formation of the new Fluid Mechanics and Thermodynamics Division and the transfer of three ceramic laboratories to the Engineering Research Building. For work in fluids there are now available a complete unit for the determination of hydraulic losses in valves and fittings, a laboratory for extensive testing of pumps and motors, and an airflow laboratory employing the hot wire technique for low air velocity studies. A blower laboratory has been constructed in temporary quarters at 3219 South State Street for testing and studying ventilating, heating, and air-conditioning.

The arts and crafts service rendered by the ceramics section in the State Street Building has been discontinued and all ceramic facilities and equipment moved to the Engineering Research Building. Approximately one-half of the space thus vacated has been made available to the Institute of Gas Technology for library purposes and the balance refitted to house the Foundation's inorganic section formerly located in the Main Building. The glass-blowing shop was also moved to larger quarters here.

Staff offices for the Electrical Engineering Division and the thermodynamics section have been constructed in the Engineering Research Building, together with the new Ohmite electrical measurements laboratory. The staff and equipment for oil analysis work, formerly in the Foundation's Main Building, have been transferred to a new location adjacent to the engine laboratory. The ceramics section, eventually to have all of its facilities in the Engineering Research Building, also has a new laboratory for glass studies, equipped with an interferometer, softening point and strain point furnaces, petrographic microscope, and auxiliary equipment. Of unusual interest in the Kiln Building are a recently completed reheat kiln which can be brought up to a temperature of 2,900° F. very rapidly for testing refractories and studying other ceramic materials, and a differentially heated continuous kiln.

At a cost of approximately $90,000, the new a.c. network calculator laboratory was completed and placed into operation on May 21.

Much special purpose equipment has been added to the Foundation's metallurgical facilities during the year including a micro-hardness tester, two heat-treating furnaces, a 150 kilovolt x-ray unit capable of making shadographs of thin sections of ferrous metals and such ordinary pieces of block metals as magnesium and aluminum, and two wire swaging machines. Also newly established in the Metals Building is a precision casting laboratory for research in the lost wax process of casting metals. Castings made by this process attained considerable importance during the war and undoubtedly will be used extensively in the future. For increased operating efficiency, the pattern shop has moved from the Metals Building to the Wood Technology Building.

On June 15 the Wire Recorder Development Corp., established to handle all commercial matters relating to the magnetic wire sound recorder, moved its loop office to the Field Building in order to obtain additional office space and a.c. current. Adjacent to the offices an attractive and well-equipped sound studio has also been constructed for demonstrating the recorder to many visitors interested in its potential uses.

Latin-American Research

Armour Research Foundation has continued its program of technological studies in Latin America which began with its full-scale industrial and economic survey of Argentina in 1942. During the past year the largest part of this work has been centered in Mexico, while a great many inquiries involving technical questions on industrial operations under development in the other Latin-American republics have been handled successfully by correspondence. Although the organization has rendered no technical services in Argentina since the military revolution, it is noted that numerous recommendations originally made to that country before the Peron regime are being put into practice under the new government as well, including the establishment of an industrial research institute for general public services.

Believed to be the only nonprofit institution of its kind conducting this type of foreign industrial research service, the Foundation has maintained this work in the conviction that technical aid to the industrialization program of our neighbor countries is essential to continued good relations, higher standards of living, and expanding reciprocal markets.

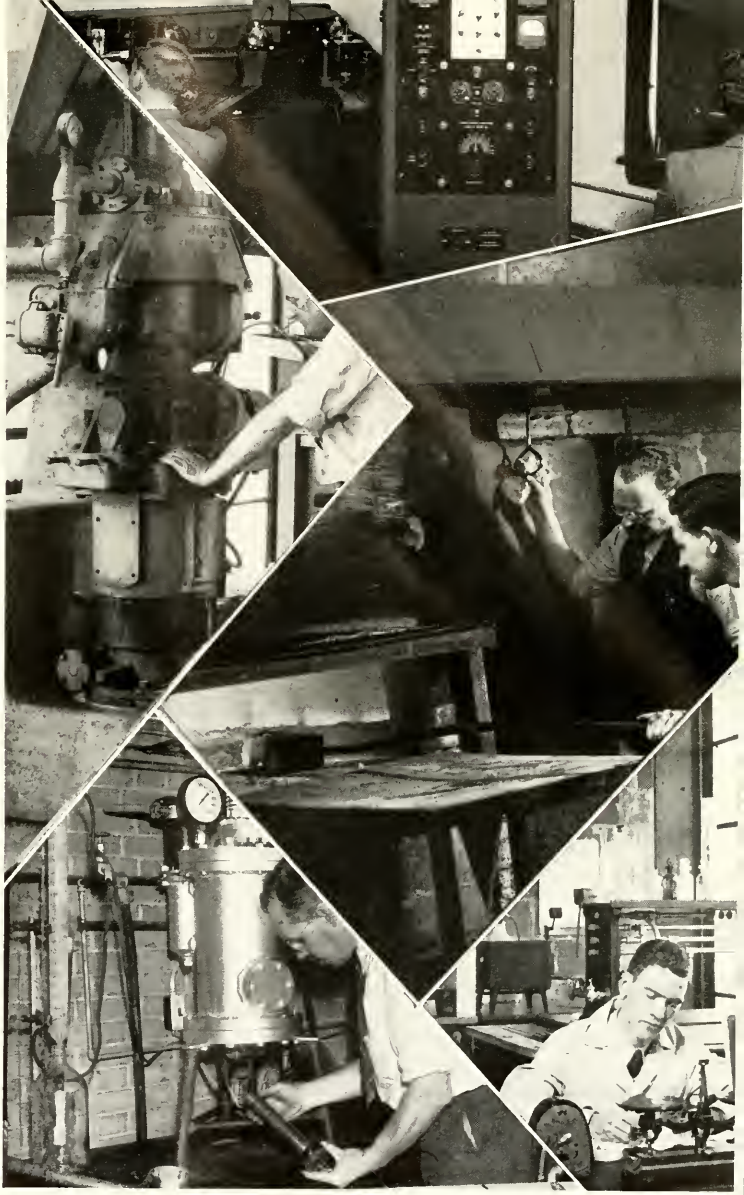
Mexican Survey. Commissioned at the start of the fiscal year by Banco de Mexico, S. A., the Foundation is now completing a basic technological audit of Mexican industries, with chief emphasis upon four major industrial groups: fibers, forest products, hides and leather, and solid fuels. The purpose of this work is to develop new industries in Mexico and to improve the existing ones in these

fields, through introduction of additional technology and the prosecution of essential laboratory research.

This study is being conducted from the Foundation's field headquarters in Mexico City, in operation since November, 1944, with a combined staff of Mexican and U. S. technologists. Field work to date has covered nearly every region of Mexico, with inspection of hundreds of industrial and agricultural enterprises as well as related undertakings in education, research, transport, and communications. Travel—which since the field group left Chicago has already totaled some 13,500 miles—is being done by automobile wherever the roads or terrain permit, since frequent stops are necessary for inspections, interviews, and the collection of samples. Both aircraft and horses must be used frequently because of distances and the inaccessibility of some areas.

From time to time the Mexican headquarters staff is augmented by selected specialists from the Foundation's Chicago staff who can contribute most quickly to certain field problems. In addition to the primary observations, detailed notes, statistics, and photographic records, numerous samples of materials are collected and forwarded to the Chicago laboratories for examination and analysis.

Although complete reports cannot be integrated until the conclusion of the work, this survey has already pointed the way to various industrial improvements and to the creation of certain new industries within Mexico. Similar advances are expected to result from the successful conclusion of the additional Mexican research programs described below—themselves a product of the survey also.



Cascalote Tannin. Perhaps the most widely used tanning material in Mexico is cascalote, related to and sometimes even referred to as divi-divi. The tannin occurs in large quantities in the pods of the tree *Caesalpinia cacolaca* found abundantly in Southwestern Mexico and certain other parts of Central America. Despite its industrial importance, until now there has been no commercial preparation of this material, so that each tanner must buy the crude pods and make his own extract or else use the unpurified ground pods themselves. Due to natural variations in tannin content, this condition results in virtually uncontrolled operating concentrations and a highly variable product.

Under the sponsorship of Banco de Mexico a research project is now in progress to overcome the several technical difficulties which have stood in the way of large-scale commercial preparation of cascalote tannin, and to make possible the establishment of an industry supplying this material to tanneries in the most acceptable form. To date this work has not only uncovered significant departures from the preconceived methods of extracting the tannin, but has also demonstrated the feasibility of recovering the fibrous waste material for incorporation into paper and cardboard.

Hard Fibers. Another program for Banco de Mexico has as its immediate objective the development and standardization of testing and evaluation methods for hard fibers, to permit better comparison of utilization possibilities and market values. The scope of this work includes not only the native Mexican fibers such as henequen (sisal), lechugilla, palma, and sansevieria, but the competing fibers of other world areas as well. The program involves correlation of existing test methods, development of new ones where necessary, and the design of special testing equipment.

A second phase of this project calls for use of the standardized evaluation methods in determining the physical and chemical properties of all major hard fibers, and the discovery of new industrial outlets for the fibers.

Henequen. A broad research program for the improvement of the economic position of henequen fiber has been authorized by Banco de Mexico and is now being started. Concerned with improvement in the processing and properties of the fiber itself and also with by-product utilization of other portions of the plant, this work is being divided by the Foundation between laboratory facilities in Chicago and in Yucatan. A cooperative arrangement has been worked out, providing an exchange of technical personnel, expansion of Yucatan research facilities, free interchange of research information, and over-all coordination by the Foundation's Mexican office. As one of the first steps, a Yucatecan research engineer has been brought to Chicago for initial study of the problem and familiarization with the Armour Plan of Research, after which this staff member will join the others of the Yucatan group for the laboratory and field work.

Quinine. Under the sponsorship of Banco de Mexico in cooperation with the Mexican Department of Health and Public Assistance, the Foundation is conducting a project to aid Mexico in producing her own supplies of quinine and related antimalarial drugs. The significance of this work is twofold, for it is designed not only to bring relief to the many malaria sufferers in that country who are now unable to obtain the needed drugs, but also to assist in rendering more productive some of the rich tropical areas of Mexico in which malaria is one of the chief hindrances to economic development.

In the State of Chiapas, near the Guatemala border, the Department of Health already has more than 60,000 cinchona trees under cultivation on an ideally situated mountainside plantation equipped with a modern nursery and experiment station. The Foundation is rendering full technical assistance in establishing the most suitable processes for large-scale extraction, pharmaceutical preparation, and packaging, and also in the creation of an adequate control and experimental laboratory at the plantation. The work of this project is being done both in Chicago and at the Mexican experiment station.

Tanning Oils. A broad research program to create specific industries in Mexico for the production of high quality oils, fats, waxes, chemicals, finishes, and other supplies needed by the leather industry has been authorized by Banco de Mexico. Many of the necessary raw materials are produced within the republic, but require studies in standardization and processing to make them fully acceptable.

The first phase of this program, concerning oils and fats used in fat-liquoring and other tannery operations, has been launched in Mexico City. Under the supervision of the Foundation, this study is being conducted through the Instituto de Quimica, a prominent research institute connected with the University of Mexico. For correlation of laboratory findings with factory practice, a leading Mexican tannery has made its pilot plant and production facilities available.

Miscellaneous Investigations. Apart from the projects described above, numerous preliminary investigations are in progress in the interests of the Mexican program. The more promising of these are intended for expansion into full-scale projects as rapidly as circumstances warrant. Included in these are studies in the properties and utilization of candelilla wax, mechanical decortication of native Mexican fibers, utilization of Mexican hardwoods, seasoning and kiln-drying of lumber, recovery of sawmill waste, by-product distillation of native woods, utilization of peat, and the manufacture of paper, cardboard, and felted fiber products from special local materials.

Additional efforts are being made to assist technically in the establishment of local manufacturing facilities for wooden specialties needed in the textile industry, and for oils and biological extracts from meat packing wastes. In the electronics field an examination is being made to determine the best means for making magnetic wire recording equipment more widely available in Mexican commercial and educational work.

Mexican Technological Development. Regarded as an important aspect of the Foundation's work in Mexico is the contribution which the organization may be able to make in the further development of local applied technology, industrial research facilities and technical education. It is for this reason that every effort is made to bring about close association of Mexican and U. S. men and facilities, both in Mexico and in the Chicago laboratories.

The beginning of the new fiscal year finds six Mexican chemists and engineers at the Foundation's laboratories: a seventh is at Illinois Institute of Technology, and three of the others are also supplementing their training with advanced courses in the Institute. Of the seven, four are on fellowships of Armour Research Foundation itself, and three hold fellowships granted by Banco de Mexico. Two are scheduled to go to other U. S. institutions for special studies in the near future, and a third will become associated with the Foundation's studies in Yucatan. All of these men, as well as others for whom plans are being made, will ultimately return to Mexico for continuous technical work.

The broad fellowship program of Banco de Mexico has these same objectives and, at this time, involves the awarding of thirty or more fellowships for specialized study in the U. S. and other countries. The Foundation, through its Mexican office and home organization, is assisting in the selec-

tion of universities and candidates, and otherwise aiding.

In two cases already mentioned, the Foundation has undertaken specific research studies through cooperative arrangements with Mexican research institutions, with a view to assisting in the development of those institutions while at the same time seeking the solutions of the research problems themselves. Simultaneously, the full facilities of the Foundation are being made available to the Mexican Department of Economy for assistance in organization and operation of the ten-million-peso national industrial research laboratory that is being built in Mexico City.

Mexican-American Conference. For October of this year Armour Research Foundation, with the cooperation of other institutions, has organized the Mexican-American Conference on Industrial Research, at which Mexican and U. S. leaders in research, industry, and finance will meet in Chicago for a week to discuss problems in industrial development, and to visit laboratories and industrial operations in Chicago and other cities. Full proceedings of this significant conference will be published.

Special Public Services

During the year the Foundation has continued to expand its services to the general public in so far as this has been possible with continued manpower limitations. Such contributions to improved living are in addition to the prosecution of industry sponsored projects, as well as the basic investigations conducted under the Foundation's own sponsorship, all of which in themselves are examined to make certain that the public stands to benefit ultimately. These public activities vary in extent from the serving by individual staff members on numerous boards and committees of civic organizations, city and state government agencies, and technical and professional societies, to the establishment of individual cooperative laboratories, such as the a.c. network calculator laboratory, and the sponsoring of conventions and other large special purpose meetings, as for example, the Mexican-American Conference on Industrial Research and the Hydraulics Machinery Conference.



X-ray diffraction dark room.

City Noise Reduction. Members of the Foundation physics staff have continued to work with the Greater Chicago Noise Reduction Council and the city's Noise Abatement Commission toward the reduction of unnecessary noises. The results of several tests and studies have been made available to the commission for use in the eventual preparation of a city code.

National Registry of Rare Chemicals. Established June 1, 1942, the National Registry, now in its fourth year, continues to render its unique free service to technical professions and industries throughout the world as a clearinghouse for information on the location and availability of rare chemicals of all types. The gratifying cooperation of scientific societies, technical journals, industry, and individuals has enabled the registry to answer satisfactorily to date between one-half and three-quarters of 8,500 requests for source information on compounds not regularly stocked by chemical supply houses. Since the registry does not buy or sell chemicals, its services to laboratories and plants in the United States, South America, England, Australia, Canada, South Africa, India, Mexico, and Hawaii are confined to locating supplies of uncommon chemicals, frequently in minute quantities, and making this information available to the inquirer. Supply sources of more than 8,000 compounds are listed in the registry.

Radio Technical Planning Board. By special arrangement two members of the Foundation's physics staff have served the Radio Technical Planning Board as members of subcommittees in connection with the studies of short-wave industrial equipment and scientific instruments and their possible interference with radio reception. The results of these investigations are being considered in the final allocation by the Federal Government of suitable wave bands for industrial purposes.

Wire Recorder Program. During the year considerable publicity has attended further developments in the broad program of magnetically recording sound on wire. Hitherto restricted entirely to a variety of war uses under the direct control of the Government, the end of the war signals the turning point in this growing industry in that civilian demands for this method of sound recording will soon be met.

To this end the Foundation, through the Wire Recorder Development Corporation formally activated on April 1, 1945, has granted licenses for civilian production to nineteen manufacturers, including one in Canada and one in Great Britain. These are in addition to the war license granted to the Government.

At the end of the fiscal year the list of civilian licensees included the following:

Aircon Manufacturing Corp., Kansas City, Kans.
Ansley Radio Corp., Long Island City, N. Y.
Automatic Electric Co., Chicago, Ill.
Boosey & Hawkes, Ltd., Middlesex, England
C. G. Conn Ltd., Elkhart, Ind.
General Electric Co., Syracuse, N. Y.
The Hallicrafters Co., Chicago, Ill.
Hammond Instrument Co., Chicago, Ill.
Meissner Manufacturing Co., Mt. Carmel, Ill.
Packard-Bell Co., Los Angeles, Calif.
Radiotechnic Laboratories, Evanston, Ill.
E. H. Scott Radio Laboratories, Inc., Chicago, Ill.
J. P. Seeburg Corp., Chicago, Ill.
Sonora Radio & Television Corp., Chicago, Ill.
Stromberg-Carlson Co., Rochester, N. Y.
Utah Electronics (Canada) Ltd., Longueil, Quebec
Utah Radio Products Co., Chicago, Ill.
Webster-Chicago Corp., Chicago, Ill.
WiRecorder Corp., Detroit, Mich.[1]

It is anticipated that a few of these licensees will be producing new civilian models by the middle of next year and that production will gradually increase in volume thereafter. Much depends upon the availability of com-

[1] Since August 31, 1945, licenses have been granted to: Rendix Aviation Corp., Baltimore, Md.; Bang & Olufsen, A/S, Copenhagen, Denmark; Pyrox Pty. Ltd., Melbourne, Australia; Steiner AG, Bern, Switzerland; George W. Borg Corp. (Gibbs Division), Delavan, Wis.; Garrard Engineering & Mfg. Co., Ltd., Swindon, Wiltshire, England; and St. George Recording Equipment Corp., New York, N. Y.

ponents such as amplifiers, speakers, condensers, etc., and the speed and facility with which manufacturers are able to tool up. It appears that the first wire recorders to be produced shortly for the public will be mainly adaptations of the Foundation's original wartime model, a portable unit complete in itself for both recording and reproducing. To be made available later will be a variety of further adaptations for many important applications, including home recording in radio receiving sets, manufacture and sale of professional records, speech training and language studies, dictation and transcription, noise level studies, transportation communication, radio broadcasting, sound pictures, court reporting, signal systems, industrial controls, commercial entertainment, public address systems, and office and plant intercommunication.

The Foundation, through its subsidiary, and a number of the licensess continue to make recorders available for certain public service activities. Units are now or have recently been in experimental use by the following: the United Nations Relief and Rehabilitation Administration for mass dissemination of instructions to dislocated populations of war stricken areas; the Department of Agriculture for making radio broadcasts in rural districts; the Library of Congress for the preservation on wire of its library of American folklore music; and the American Foundation for the Blind in study courses and entertainment for the sightless. With increasing recorder production it is expected that many similar public service activities may be aided in this manner. Of particular interest has been the presentation of a wire recorder by one of the licensees to the President of the United States for his personal use. Another will be presented to the President of the Republic of Mexico on the occasion of the Mexican-American Conference on Industrial Research.[1]

Armour Research Foundation continues to expend its own funds and employ a considerable number of its staff members in an extensive program of recorder research and development. These activities relate to both the fundamental and applied aspects of magnetically recording sound, and include: improvements in recording, erase, and playback heads; master recording; constant wire speed; improved wire; and multiple recording. Under its licensing agreement the Foundation provides all licensees with the details of these developments through the preparation of engineering and technical bulletins and periodic meetings of all recorder manufacturers; they, in turn, plan to maintain certain standards of uniformity to permit the widest possible application of the instrument.

Industrial Research Projects

Since the beginning of the fiscal year, fifty-eight new long-term research projects have been undertaken: additive removal characteristics of engine lube oil filters, alloy plating, anomalous x-ray diffraction, chintz, cinchona alkaloids-quinine, corrosion resistance, cotton warp size, cylinder wear devices, decalcomania paper and ink, dryers, dye tablets, electrical insulation, electric lamps, engine vibrations, engine wear tests, fluid mechanics, fruit conveyors, hardenability of steels, hard fiber standards, high pressure, high-temperature broiler, internal combustion engine for aircraft lube oil evaluation, lacquer and water color paints, linseed oil, lubricants, lubricating oil identification, magnetic measurements, magnetic sound recorder wire, mechanics, Mexican technological survey, network calculator, orange oil, organic dielectrics, ozone, polyvinyl esters, precision measurements of electrical quantities, rubber, silica gel, slush pump liners, spectroscopy, speed control, switch operations, tanning extracts-cascalote, theory of flight, tractor seat location, transformers, vacuum tubes, V-belts, voltage regulators, washing machines, white ware bodies, wire recorder magazines, wire testers, x-ray diffraction, year-round air conditioning, and three confidential security projects.

During the year forty-one projects, including thirty-five carried over from the previous fiscal year and six initiated in 1945, were completed: abrasives, airport loading, airport paving, bolts, cathode ray tube screens, cellulose, clays, core binders, core boring, cranes, cylinder wear devices, dolomite, dye tablets, electroplating, fountain pens, fractional horsepower commutator motors, fuel additives, glass fibers, impact studies, insecticide dispensers, intake silencers, magnesium forging, magnetic measurements, magnetic recording wire, mica, multiple recording, piston ring gage, powdered metals, stenographic devices, theory of flight, wall paper, waterproof fiber containers, wire recorder magazines, wire recorder production, wire testers, wood, and five in confidential fields.

Ten projects are under temporary suspension to permit enlarged military research: cigar lighters, computing machines, cranes, dynamic loading, gas containers, golf equipment, noise reduction, open hearth furnace slags, pipe bends, and spraying tools.

In all, 141 major research projects have been in operation during the year, exclusive of the ten under suspension. One hundred and ten projects continue into the coming year, including fifty-two of the new ones already listed, the ten suspended, and forty-eight of from one to seven years' duration. Those of the last named group are: acoustic tubes, aluminum casting, automobile air conditioning, boiler descaling, boiler water conditioning, bushings, candy, cast valves, chocolate, compressed gases, container glass, counting devices, cutting oils, crucibles, dental products, Diesel engine indicators, die steel, drum closures, dry corn milling, electrical networks, electrical weighing, electronic gas analysis, electro-tinplate, engine couplings, engine lubricants, enzymes, fibers, filters, flexible shafting, fluid pumps and motors, industrial process war aids, lithography, metal detection, metal finishing, potash, protective coatings, quenching oils, starch conversion, steel castings, thermocouples, turntables, vacuum tubes, watch technology, welding supplies, wheat, wire drawing, and two on confidential subjects.

Following are the projects on which progress can be reported during the

[1] Presentation of the recorder was made during the closing session of the Conference on Oct. 6, through the Mexican Secretary of National Economy.

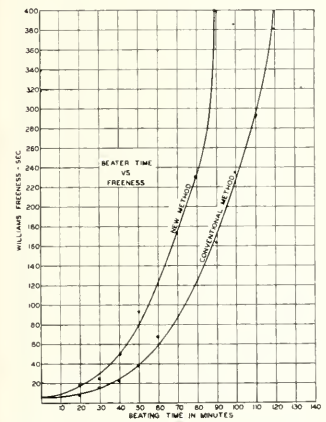
year. In each case the individual industrial sponsor has agreed to the release of this information which, in most instances, must remain general.

Chemistry and Chemical Engineering Research

Boiler Water Conditioning. The investigation of boiler water conditioning compounds, sponsored by the Dearborn Chemical Co., is in its third year. A number of active boiler compounds have been synthesized and their potency tested in an experimental boiler.

Studies have been directed toward improvement in yields and in methods of isolation of these compounds.

Figure 3.



Pure compounds and by-products were identified by application of microscopic and x-ray diffraction techniques, in addition to the more conventional organic methods.

A study of the relation of molecular structure to boiler activity is under way. Increased boiler efficiency is observed in compounds in which long-chain aliphatic groups are attached to molecules containing centrally located polar groups.

Candy. A study of control methods in the cooking of various types of candies is now in its second year. A number of control methods have been evolved and are in various stages of development, one of which has proved satisfactory in actual plant operation.

An investigation of methods of evaluating cooked starch gels is in progress. Several devices have been designed to adapt well-known principles to the materials used in candy manufacture. Another phase of this work has consisted of a study of the application of existing devices for use in the testing of candy products.

Cathode Ray Tube Screens. A project for the Philco Corp. on the study of the chemical behavior of phosphors for cathode ray tubes has been completed during the year. This program has studied methods of preparation of phosphors, firing techniques, fluxes, and activators. A considerable portion of the work was devoted to a study of the crystallographic and chemical changes which take place in various phosphor materials during their preparation, firing, and excitation.

Cellulose. A survey of certain agricultural waste materials suitable for production of high grade cellulose was completed during the year for the Sylvania Industrial Corp. While the feasibility of this method of manufacturing cellulose was definitely established, cost estimates showed that processes using waste materials could not compete favorably with current sources of cellulose.

Chocolate. This project is now in its second year. A study of purification methods of sugar used in candy manufacture has resulted in the development of a new method of purifying raw sugar. This method will result in considerable savings in the manufacture of candies in which the purified product can be used. Pilot-plant evaluation of the method is now in progress.

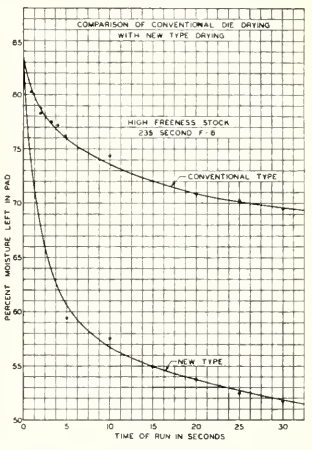
Cinchona Alkaloids—Quinine. In cooperation with the Public Health Department of Mexico and Banco de Mexico, a study of the cultivation of cinchona trees and the processing of the bark into malaria-controlling cinchona alkaloids is under way.

Methods of analysis of the bark are being studied to evaluate their accuracy and to develop a rapid, dependable analysis for use in plant breeding studies. Processing and packaging methods will be developed to give an economic, local source of cinchona alkaloids for malaria control to facilitate the development of the potentially rich Mexican tropics.

Compressed Gases. Entering its fourth year, a study of the behavior of certain gases under pressure is rapidly nearing completion. Extensive plant tests have substantiated laboratory scale experiments indicating improved service from commercial gas cylinders. Benefits of this improved service should accrue not only to the sponsor, but also to consumers.

Decalcomania Paper and Ink. The rapid drying of ink on decalcomania paper is being investigated for The Meyercord Co. of Chicago, Ill. Dielectric heating, infrared heating, and two entirely new methods of drying are included in the investigation.

Figure 4.



Dental Products. The study of dental products is in its second year. Dental plastics, as well as other dental products, are being investigated with the object of improving and adding to materials now being used in dental practice.

Drum Closures. Entering its eighth consecutive year, the project sponsored by the American Flange & Manufacting Co., Inc., continues to be concerned with the improvement of gasket materials and their proper application in the shipment of many types of industrial commodities. Corrosion studies throughout the year augmented this program.

Electric Lamps. A project for developing improved methods of attaching carbon filaments to lead-in wires in carbon filament lamps was under-

taken for the North American Electric Lamp Co. A method in which the tips of the filaments were plated and then spot-welded to the lead-in wires was worked out. This process is now undergoing plant tests.

Enzymes. Under the sponsorship of the Rahr Malting Co., a study of the manufacture and use of various types of amylolytic and proteolytic enzyme systems is now in its third year.

Major emphasis on this project is at present being placed upon the utilization of various fungal enzymes in industry. A fundamental study of fungal amylase systems is under way to evaluate the possibilities of the much publicized mold bran for use in the manufacture of industrial alcohol. Some progress has been made in the chemical evaluation of mold bran which has been considered of no value for fungal amylase systems.

Fibers. In the fourth year of the project sponsored by the Hawley Products Co., St. Charles, Ill., two new processes were developed for factory use. The first, a new type of beating, provides high freeness stocks of greater strength in 20% less time. The second, a new method of drying, provides rapid removal of water from fibrous articles. The speed of removal is not greatly affected by the degree of hydration. Approximately 18% more water is removed by this new method than ordinarily in the same time period.

Figs. 2 and 3 illustrate the effects of these two new processes.

Filters. A research program for The Cuno Engineering Corp., Meriden, Conn., on the problem of filtration, is now entering its fourth year. Fundamental studies of animal, vegetable, and synthetic fibers and their properties as effective filtering media for fuel oils, lubricating oils, and hydraulic fluids have been undertaken. A comprehensive study of the better commercially available filters in these fields has been made. Several new filters have been developed which will be in commercial production in the near future.

Foundry Core Binders. The original purpose of the project for the Quaker Chemical Products Corp., Conshohocken, Pa., the development of a new type of foundry core binder, has been completed. The new core binder has a considerably higher dry tensile strength and comparable green strength in comparison to several binders generally used.

During the year part of the work has been concerned with the effect of different types of sand on both the green and baked strengths of a binder. Studies were made to determine the proper percentages of binder to obtain the desired formulations with sand submitted by the sponsor.

Hard Fiber Standards. Another project sponsored by Banco De Mexico has for its purpose the establishment of standards for hard fibers and is now in progress. The program includes development of new, and adaptation of existing tests for hard fibers —e.g., henequen, yucca, and sisal— native to Mexico. The resulting standards will be based on the physical properties of the fibers as determined by microscopic measurements and mechanical tests.

Industrial Process War Aids. As in the previous year, the Foundation has continued to lend scientific assistance to the Industrial Processes Branch of the OPRD. Specific attention was given to the development of waterproofing of pasteboard containers for use in overseas shipment and the conversion of laboratory data into plant production. Assistance was also given in the fields of colloidal fuel and materials to substitute for tarpaulin.

Lacquer and Water Color Paints. The rapid drying of lacquer and water color base paints on paper is being investigated for Western Printing and Lithographing Co., Racine, Wis. For this purpose, high drying temperatures must be avoided and a new method of drying at low temperature is being developed.

Linseed Oil. Research on linseed oil, sponsored by the Minnesota Linseed Oil Paint Co., has recently been established. A comprehensive investigation of rapid polymerization of linseed oil is under way.

Lithography. With the centering of research activities of Lithographic Technical Foundation at Glessner House, a large part of the investigational work currently under way at Armour will be transferred to LTF's new quarters.

In addition to the intensive program in the metallurgical division for improving grained metal plates, the chemistry division of Armour Research Foundation has been active in investigating several phases of the lithographic processes.

Lithographic printing involves the repeated transfer of an image from a hydrophobic ink surface while the nonprinting portion of the plate is maintained in a hydrophilic condition. To accomplish the latter, an aqueous fountain solution is employed. In view of the variation in the composition of these solutions throughout the industry, fundamental studies are being made to determine the effects of various ingredients in the solutions upon grained metal plates. The development of a means of composition control for the industry and the use of corrosion inhibitors for protecting the metal plates are also being considered.

In the plate-making process, during which an image is formed on a plate coated with a bichromated colloid, the rate of hardening of the coating is particularly sensitive to variations in humidity. A broadening of existing correlations is being carried out to secure proper exposure of plates under any atmospheric conditions which may be encountered.

It is also important in plate making to obtain maximum desensitization (ink repellency) of the nonprinting areas and efforts are being made to improve this procedure by modifying the desensitizing solution and the process.

Lubricating Oil Identification. A project sponsored by the Pennsylvania Grade Crude Oil Association has for its objective the development of analytical methods, based on chemical and/or physical techniques, for the differentiation of lubricating oils refined from different crudes. Special emphasis is being placed upon analytical methods which permit definite identification of particular lubricating oils derived from Pennsylvania Grade crudes.



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The results of the research of the American Gas Association and Gas equipment manufacturers are made available to industry by the Industrial Gas Engineer of the local Gas Company. He can help secure faster, more efficient, more economical manufacrure of improved products.

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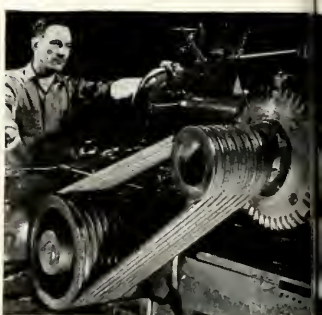
1 Early in war, A-C's work with tric power helped to solve se war shortages. For instance, light metal industries faced problem: *How to boost outpu aluminum for fighting planes?*



5 To aid plants in figuring substation needs, A-C introduced a system of visual planning—*scale model layouts of power units and switchgear*—elim-inated hours of paper work, comple tables, drawings!



6 New alternating-current welder, developed by A-C, gave shipbuilders and construction men important new production tool—used power more efficiently without converting to direct current.



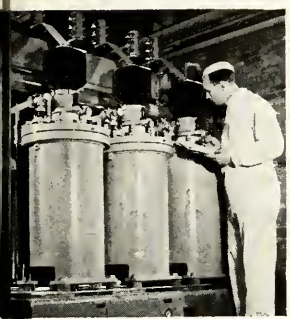
7 The multiple V-belt drive is ano example of engineering leaders Invented by Allis-Chalmers, to these power-saving belts drive 7 of all U. S. machines *regardles what they produce!*

TURN ON THE POWER FOR RECONVERSION!

Call on Allis-Chalmers' new War-Born Products and Technique for help with Technical Problems. At your command is the wide range of Industrial Knowledge and Equipment in the World.

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

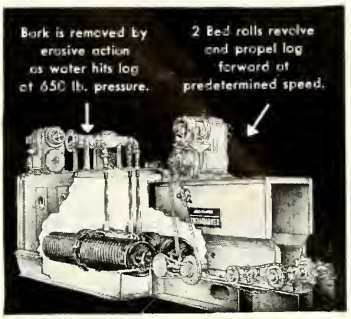
N POWER!



The answer was the Mercury Arc Rectifier — huge electronic device that reliably converts a-c to d-c current for electrolytic production of light metals. It was first introduced by Allis-Chalmers engineers!



3 Another electronic war development —*A-C's high-frequency Induction Heater*—greatly facilitates brazing, hardening and annealing of many small metal parts—saves time and work for metal-working industries!



4 To help relieve a paper shortage, A-C developed the Streambarker (unique machine using water pressure from power-operated pumps to strip bark from logs)—saved mills tons of precious wood pulp.



In steel plants, "Regulex" Control, developed by A-C, helped boost output of alloy steel for war use—by automatically controlling electric furnace temperature, making possible extra "heats," lower "melt" costs.



9 Today, on A-C drawing-boards are plans that put these *and many other* A-C war products to work for peace —will help lower unit costs, produce better clothing, food, cars, home needs *by putting more power to work.*

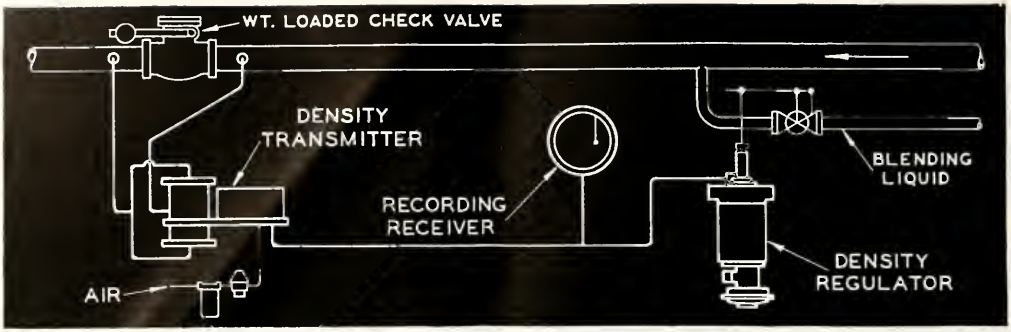


10 Coming to every field: more efficient methods and equipment for generating, distributing and using electric power thanks to A-C engineering! Call your nearby A-C office.

ALLIS-CHALMERS

PRODUCER OF THE WORLD'S LARGEST LINE OF MAJOR INDUSTRIAL EQUIPMENT

Tune in the BOSTON SYMPHONY Every Saturday, over the American Broadcasting Company Coast-to-Coast, 9:30 P. M., E. S. T.



Typical installation for measurement and regulation of density.

REPUBLIC PNEUMATIC LIQUID DENSITY TRANSMITTERS

The Republic Pneumatic Density Transmitter employs the force-balance principle to establish an air pressure which varies proportionately to variations in density of a liquid flowing in a line. The air pressure is therefore a direct measure of the density and can be conducted to a remote location by means of small tubing. A receiver gage connected anywhere in this transmission line will show the variation in the density, and may be used as the impulse for actuating an automatic regulator.

The Transmitter can also be furnished for direct submersion in a tank or vessel, either open to atmosphere or under pressure.

OPERATING ADAPTABILITY

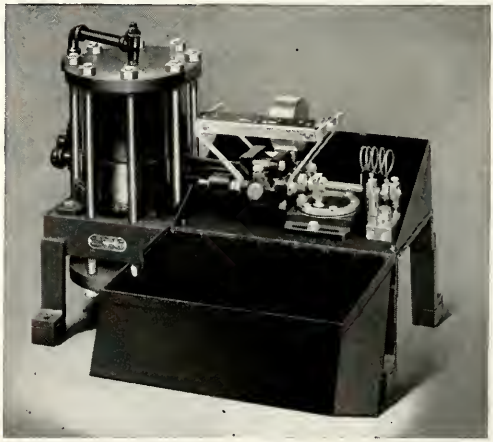
RANGE—Transmitters can be furnished for liquids of densities from 0.5 sp. gr. (compared to water at 60° F.), to the heaviest liquid known.

OPERATING RANGE—Can be as small as 0.05 sp. gr. and this may be from any base density. For example, range may be 0.6 to 0.65; 2.5 to 2.55; etc. Maximum spread may be any amount necessary; e. g.—0.6 to 3.0; 0.8 to 3.5; etc.

RANGE CHANGE—The base density may be changed approximately 3 to 1 by shifting the operating range adjustment weight. For example, the instrument may be built to show a change of 0.05 (or other range spread) above base densities from 0.6 to 1.8, the value of the base density being determined by the position of the adjustment weight.

The spread of the operating range can be changed approximately 3 to 1 by changing the position of the reaction diaphragm along the weighbeam. The base of the reaction diaphragm chamber is slotted to facilitate this change. The spread may be changed approximately 10 to 1 by changing the size of the reaction diaphragm. This change is easily made by changing the diaphragm plates, thereby changing the effective area of the diaphragm.

OPERATING PRESSURE—The standard transmitter is designed for operating pressures to 150 psig. Special designs are available for pressures up to 7500 psig.



The Republic Liquid Density Transmitter with cover open.

PERFORMANCE

ACCURACY—Output pressure vs. measured density is guaranteed accurate to ½ of 1% of range spread.

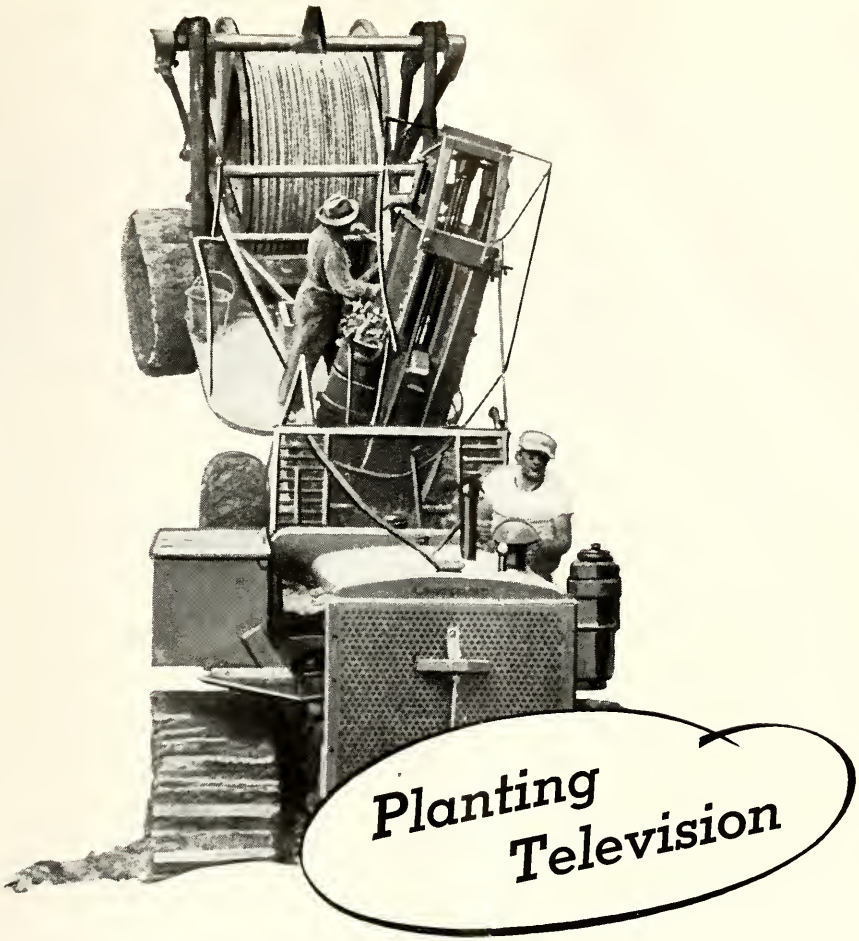
SENSITIVITY—Since the ratio of available force to effective friction is very large, and the motions required for complete operation are very small, the net dead spot in the mechanism is so small as to be undetectable by ordinary means, being less than 1/20 of 1% of minimum range spread of 0.05 sp. gr.

RESPONSIVENESS—At recommended sampling velocities, 90% of a change in density will register at the transmitter output in 15 seconds.

WRITE FOR BULLETIN NO. 44-10

REPUBLIC FLOW METERS CO.

2240 Diversey Parkway, Chicago 47, Illinois



Planting Television

ABOUT 7,000 miles of coaxial cable will be added to our plant during the next few years. Inside each cable are six or eight copper tubes—each pair a broad communications highway for two television programs or nearly 500 long distance telephone calls. Giant plow-trains will "plant" much of this cable deep in the ground—safe from storm and fire.

This construction is but a part of our activity in the television field. Now in an advanced experimental stage are plans to link coaxial cables and high frequency radio relay systems to provide a nationwide television network.

Our part in television is the transmission of programs from one station to another. As this new industry develops, the Bell System will be prepared to provide whatever network facilities are needed.

BELL TELEPHONE SYSTEM

Metal Finishing. Upon completion of the development of accurate test methods and equipment for evaluating metal finishes, the equipment has been transferred to the sponsor's laboratories for use in production problems and control. It is planned to maintain close contact with this work with a view to establishing, within a year, the second phase of the broad objective—i.e., the improvement of metal finishing materials.

Orange Oil. The Food Machinery Corp. is sponsoring research on the industrial utilization of the components of whole orange oil. A comprehensive survey has been made and emphasis is being centered upon the terpenes present in the oil.

Organic Dielectrics. Research on new organic dielectrics is being sponsored by the Line Material Co. The Foundation's electrical engineering division has developed equipment for evaluating the electrical properties of the materials as they are developed and electrical tests are under way.

Protective Coatings. This project, sponsored by the Page Steel and Wire Division of the American Chain & Cable Co., Inc., New York, N. Y., is in its second year and has as its goal the development of coatings which will be highly resistant to weathering and abrasion and, in addition, have a distinctive color and "eye appeal." Many types of coatings have been studied during the past year. The work has involved comprehensive studies on the light stability of pigments, pigment-vehicle ratios, metal deactivators, catalysts, and other variables which will lead to the formulation of a coating having optimum properties. A coating apparatus has been designed and installed for a study of this phase of the problem.

Quenching Oils. A project on the study of quenching media for the Shell Oil Co. has completed its second year. Several precise methods of evaluating coolants have been developed.

Rubber. A new project sponsored by the Wyandotte Chemical Corp. has been undertaken to study the dispersion of calcium carbonate in carbonate-reinforced rubber. This investigation has involved particle size and dispersion studies of the original pigments and pigment dispersions in rubber by means of the optical and electron microscopes. The information will be used to develop carbonate-reinforced rubber with improved physical properties.

Silica Gel. In order to develop an improved and more versatile type of silica gel, all of the various phases in the manufacture of this material are being studied under the sposorship of the Sterling Silica Gel Co., Sterling, Ill., both on a laboratory and on a pilot-plant scale. Attention is also being directed toward the development of new products conforming to the sponsor's general production processes. Information in the literature on the manufacture, properties, and uses of silica gel has been collected to aid in evaluating the postwar situation of this material in relation to that of other solid adsorbents.

Tanning Extracts—Cascalote. A third project sponsored by Banco de Mexico concerns the development of better utilization of the cascalote bean, a native Mexican tanning agent. This research, which has been in progress for several months, has resulted in a promising process which allows separation of the bean into a 60% tannin concentrate and a clean, espartolike fiber, adding a valuable by-product to the processing of cascalote.

Studies of stabilizing agents with cascalote reveal considerable promise for the use of several stabilizers to prevent excessive fermentation.

An experimental leather processing laboratory is being assembled for use in evaluating tanning materials, and a pilot-plant extraction unit has been built.

Textiles. Research on the project sponsored by The Johanna Textile Mills, Goldville, S. C., now in its third year, is being continued in four major phases.

The study of starches for use in tracing cloth described in the 1943-44 Annual Report was inactive during the major portion of 1945 pending the arrival of equipment for the erection of a starch-treating plant. At present this plant is being completed and will be in operation shortly.

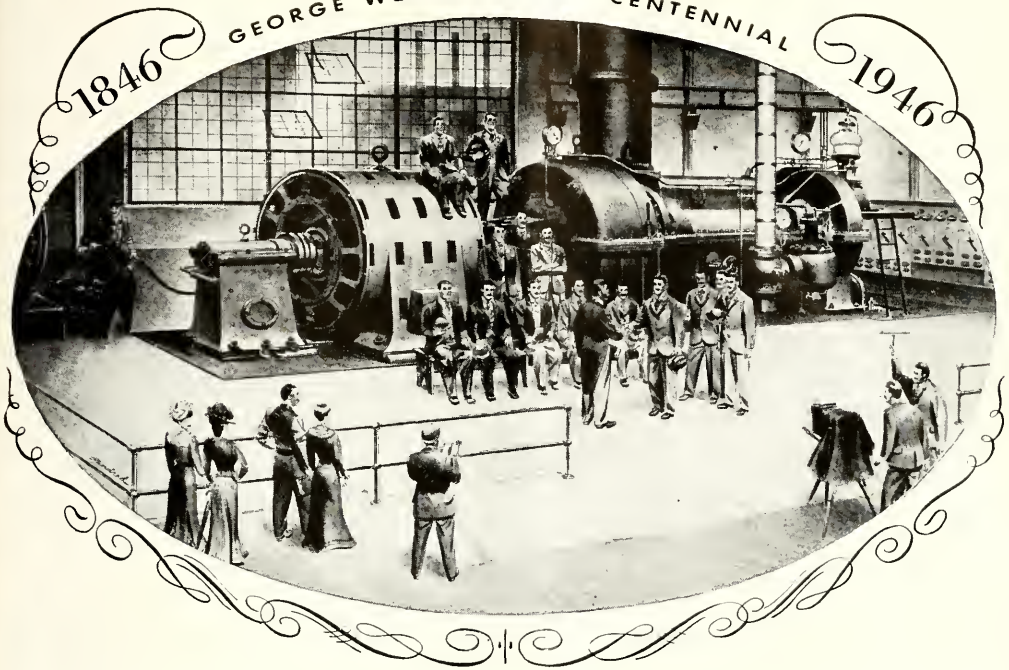
Work on the development of a water soluble cotton warp size was continued during the year. In order to test thoroughly the size material developed in the laboratory, it was necessary to design and construct a laboratory slasher to size a sufficient quantity of yarn for full-scale weaving tests. Approximately 1,400,000 yards of warp yarn were sized on this slasher and sent to the sponsor's plant in Goldville, S. C., for weaving tests. The yarn sized with the water-soluble compound gave a weaving performance better than yarn sized with the conventional starch material. The most noticeable feature of the new size was its ability to prevent all shedding of lint on the looms. After thirty hours of operation, there was still no evidence of lint. The new size is unaffected by atmospheric changes and can be used under lower humidity conditions than commonly employed in weave rooms. It is removable from the cloth by washing in warm water, and can be stored in solution form for long periods of time. A comparison of the strength and elongation values for starch size and water soluble size follows:

Average of Several Hundred Determinations

	Tensile Strength, Ounces	% Elongation
Starch size	11.0	4.1
Water-soluble size	10.9	6.2

During the past year, an investigation has been carried out covering the manufacture of glazed chintz. Two new glazing materials have been found which will permit the elimination of two steps in the manufacture of glazed chintz. One material produces a surface which is equal in soap-resistance to that of commercially available chintz and the other appears to be superior in soap-resistance and durability. A friction calender was installed during the year which aided greatly in this investigation.

New methods have been developed for the preparation of suspensions of organosols (VYNU resins) for cloth coating. These consist of surface-gelled resin particles suspended in a mixture of plasticizer and suitable hydrocarbons, whereby a nonvolatile content ranging from 65 to 75% is



WHIRLING POWER

EARLY in life, George Westinghouse dreamed of a new and better source of power that would make obsolete the ponderous *reciprocating* steam engine of his day.

Even as a boy he had wrestled with the problem—securing his first patent on an engine of the *rotary type* when only 19 years old.

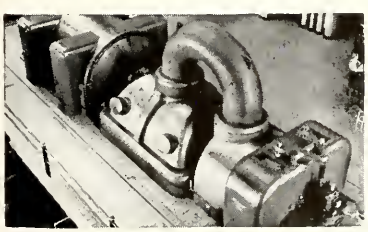
Years later, Westinghouse heard the exciting news about a *new type of rotary engine,* developed by Sir Charles Parsons in England. It was a steam turbine . . . using *jets of steam* to drive whirling blades.

Here was the answer to the problem that had fascinated Westinghouse since boyhood—and he promptly acquired the rights to manufacture the turbine in America.

The next few years were busy ones for George Westinghouse. With characteristic energy, he applied all his inventive genius in developing the still crude steam turbine into a *compact power source* for generating electricity.

Then, in 1900, Westinghouse installed a 2000-kilowatt steam turbine generator at Hartford, Connecticut—by far the largest then in existence.

It was the *first* practical central station turbine generator in America . . . a *new* application of whirling power that was to bring electricity to people all over the world.

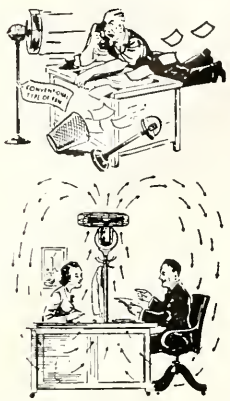


Westinghouse
PLANTS IN 25 CITIES OFFICES EVERYWHERE

TODAY . . . America annually produces more than two billion kilowatt hours of electricity and more than three-fourths of the generating capacity in America is in steam turbine generators. Westinghouse manufactured a large share of these turbine generators—some developing more than 200,000 horsepower each. In 1946, more than a million horsepower of Westinghouse steam turbines will go into American power plants.

Tune in: JOHN CHARLES THOMAS—*Sunday, 2:30 pm, EST, NBC* • TED MALONE—*Monday through Friday, 11:45 am, EST, American Network*

WHY DO Reco
AIR CIRCULATORS
RADI-AIRE
BLOW UPWARDS?

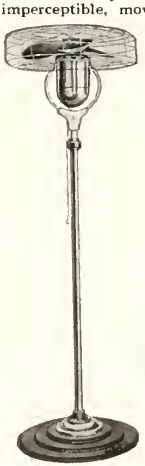


Strange to say, numerous experiments have definitely proven that to obtain complete air circulation in a room, the fan must blow upwards. It cannot be obtained by horizontal blowing or oscillating fans.

Better Comfort Cooling

The RECO blows upwards, the air traveling along the ceiling, down the walls and up the center again. This produces continuous, gentle air circulation in every portion of room. Much greater comfort cooling is obtained as the entire body is constantly bathed in imperceptible, moving air. And there are no drafts to cause sore throats or blow light material about.

This circulator is also highly desirable for refrigerated spaces and processing rooms.



Cut No. 1915 at the left is a RECO High Stand Model. It is 6 ft. high adjustable to 8 ft. Also obtainable in table and ceiling models.

Send for free copy of booklet "The Magic Heating and Cooling Plant of the Human Body."

REYNOLDS ELECTRIC COMPANY

2625 W. Congress St.
Chicago 12, Ill.

readily obtained. Moreover, these new suspensions have been found to have a stable viscosity when kept in storage. These outstanding characteristics —a high nonvolatile content and a stable viscosity—should make it feasible to coat cloth in a one-step procedure, a distinct advantage over the solution coating process in which several coats are applied in order to obtain a satisfactory surface.

Wheat. During the fourth year of this project, a critical survey of the analytical methods of cereal chemistry has been completed. This survey, carried out to evaluate methods for use in studying the chemical changes taking place in flour during aging, has resulted in more accurate knowledge of the sensitivity of numerous methods and has led to the development of several interesting modifications of standard techniques in cereal chemistry.

The aging study now in progress will contribute to the knowledge of the chemical changes which take place in flour after milling. Elaborate precautions to ensure uniformity in sampling and storage conditions have been taken throughout the study, which will extend into next year.

Special Service. For the purpose of rendering to industry generally, as well as to the internal organization of the Foundation, a complete and integrated analytical service, there has been established a group of scientists highly skilled in the techniques of spectrography, wet chemical analysis, x-ray diffraction, optical crystallography, microscopy, and physical testing. While actually assigned individually to the various major divisions of the Foundation, these staff members also function as a unit of the chemistry division under a coordinating supervisor.

For the exhaustive determination of the composition of matter, both qualitatively and quantitatively, this arrangement permits the efficient use of relatively recent developments in equipment and knowledge relating to the physical properties of substances, such as crystal structure and the absorption spectrum. In many analytical problems it is impossible to arrive at correct conclusions unless it is understood how the various elements in a mixture are combined. This can best be accomplished by determining the characteristic physical properties of the solid phases, usually by x-ray or optical crystallographic techniques, and these determinations, together with the original spectrographic and wet chemical studies, amplify and supplement each other to provide complete and accurate analyses unobtainable by any other means. Not only are the actual constituents of matter revealed by such physical analysis, but much additional information is obtained with respect to polymorphic form, particle size, and particle shape to explain the behavior of solids, as for instance, the covering power of paint pigments, the abrasive or polishing action of fine particles, and the dispersion of reinforcing pigments in rubber.

Metals and Ceramics Research

Aluminum Casting. Progress has been made in the study to determine the various causes of pin hole porosity in aluminum castings, under the sponsorship of Ebalov Foundries, Inc., Rockford, Ill. Methods have been evolved to minimize this commonly recurrent fault of aluminum castings. Various tests to check the porosity of aluminum castings now being produced show gratifying results.

Exceptionally sound aluminum alloy specimens have been cast using a pressure method and controlled rates of filling metal dies under unique atmospheric conditions, thus eliminating any opportunity of oxidizing the metal during the process of casting. This method also prevents water vapor from contaminating the melt and liberating hydrogen, which is the cause of much of the porosity in aluminum castings.

Boiler Descaling. This project, undertaken on behalf of the Butler Engineering Co. of New Orleans, and continued for its second year, had two principal objectives: to determine the actual mechanism by which the electrolytic unit prevents the formation of hard scale in boilers and to improve and extend the range of condi-



RCA Laboratories provides another great achievement in television—the "mirror-backed" Kinescope, or picture tube.

New "searchlight brilliance" for home television!

Now, large screen television pictures are twice as bright—yes, *twice as bright* as ever before!

You can "count every eyelash" in the close-ups. You'll almost want to shake hands with the people on your television screen—so great is the illusion that they are actually in your living room.

This new sharpness and brilliance is achieved through the new RCA "mirror-backed" Kinescope, or picture tube, perfected at RCA Laboratories.

It has a metallic film—eight-millionths of an inch thick. This metallic film acts as a reflector, allowing electrons to pass through to the screen but preventing light rays from becoming lost through the back of the tube. Just as the reflector of a searchlight concentrates its beam—so does this metallic film reflector double the brilliance and clarity of detail in home television receivers.

Similar progress-making research at RCA Laboratories is being applied constantly to all RCA Victor products—assuring you that anything you buy bearing the RCA monogram is one of the finest instruments of its kind science has achieved.

* * *

Radio Corporation of America, RCA Building, Radio City, New York 20. Listen to The RCA Victor Show, Sundays, 4:30 P.M., Eastern Time, over the NBC Network.



RCA Victor home television receivers will be available in two types. One model will have a direct-viewing screen about 6 by 8 inches. The other type will be similar to the set shown above—with a screen about 15 by 20 inches. Both instruments are being readied for the public with all possible speed and should be available this year.

RADIO CORPORATION of AMERICA

tions under which the unit will operate successfully. A theory of the mechanism by which the descaler prevents the formation of hard scale has been formulated and confirmatory tests appear to validate the proposed theory. A high-pressure boiler has been built to allow tests to be conducted in the laboratory which can approximate the temperatures and pressures found in industrial boilers. Improvements in the unit can be tested in the laboratory boiler and the effect of variations in water and materials can be followed. In the application of the results of this investigation to actual practice, it is hoped to make available to industry soon a more efficient and economical means of boiler scale prevention.

Container Glass. The third year's work on container glass for The Liberty Glass Co., Sapulpa, Okla., continued with the study of composition and its effect upon the physical properties of the glass. Research work on other phases of container glass manufacture was also started during the year with favorable progress made.

Corrosion Tests on Compressed Gas Cylinders. The Harrisburg Steel Corp. is interested in increasing the life of steel cylinders used where corrosive conditions are severe. Accordingly, a series of corrosion tests on tanks given various treatments is in progress to determine what might be done to preserve the tanks when they are sent to certain locations. It is likely that the life of tanks will be extended in all services by the treatments found necessary for satisfactory service under adverse conditions.

Crucibles. The Vesuvius Crucible Co., Swissvale, Pa., has sponsored a project for the improvement of graphite crucibles, for the specific purposes of lengthening the life of crucibles and increasing the speed of metal melting. To achieve these ends, experiments have been conducted in which previously untried materials have been added to bodies already in production. Attempts have also been made to develop a new body.

Die Steels. The A. Finkl & Sons Co. project continues into its third year. Having established the reason for the exceptional hardenability of Cu-Pro-Die steel by means of the "S" curve, the investigation continues with the study of other compositions.

The heat treating of large sections of steel, as commonly encountered in the manufacture of die blocks and large forgings, requires that the scientific approaches to hardenability be added to the skill and art of the last decade. Knowledge of the behavior of steel is best summarized in terms of the "S" curve originated by Davenport and Bain.

Many time-consuming annealing cycles and hardening treatments have been replaced by short time cycles predicted from the "S" curve.

Electrotinplate. A fundamental study of the corrosion of tin plate is currently in progress. Several techniques are employed, including weight loss studies on tin-steel couples and directly measured polarization curves of the various materials involved in tin plate production. By the direct study of both the anodic and cathodic polarization characteristics of tin and of the several steels used in manufacturing tin plate, it is hoped that general practical information may be accumulated with regard to the influence of different types of steel on corrosion.

The electrolytic plating weight tester which was developed some time ago has been greatly improved. It is now possible to measure automatically the tin plate thickness of a specimen with remarkable accuracy. The instrument is being successfully adapted to the measurement of coating weights of other metals, including zinc, cadmium, lead, and chromium.

Lithographic Grained Metal Plates. The fundamental nature of this project, one of several for Lithographic Technical Foundation, becomes immediately apparent. Initially, a survey was made of grained metal plates for lithography by collecting a representative set of plates currently used. This set of samples was enlarged until it became national in scope.

Plate materials were found to be standardized, being either a grade of soft zinc-base or a grade of soft aluminum-base metal, but a divergence in type of grain was apparent. One plant was noted to be performing successful press work with a relatively fine grain; another was getting equally satisfactory results with the use of a relatively coarse grain for proving. This was contrary to the belief that fine grain was mandatory for proving while press work required a somewhat coarser grain. Other instances were then brought to light to indicate satisfactory proving and press work on the same type of grain.

With the idea of eventual specifications for grained plates, the samples from the field were given certain measurements. With respect to grain depth, micrometer measurements were checked against photomicrographs, and it was found that what was normally considered a fine grain was about 0.0005 inch deep, and what was considered coarse, for normal press work, was about 0.001 inch deep. It was also found that the spread of a grain was in the range of three to six times its depth, regardless of whether fine or coarse. Profile photomicrographs were secured from which to note grain shape.

It was soon revealed that grain depth, size, and shape, the so-called macrocharacteristics, were but a few of the variables determining suitability of a plate for litho work. For instance, a plate which had given 300,000 impressions and which was spent because of inability to continue to hold water upon its nonimage area, as used in lithographic printing, had almost the normal macromeasurements of an unused plate. It was apparent that micro or submicro qualities had changed. These qualities involve the total surface area of a plate and the film placed upon that surface by the atmosphere or by other chemical treatments.

These studies of the currently popular method of plate graining are being made concurrently with studies of other types of graining processes, such as grit blasting and chemical graining, introducing in each case a new table of variables for study.

A grained plate has in the past been prepared for use by cleaning, or

One reason why television is coming fast...



YOU are looking at two bell-shaped cathode ray bulbs mass-produced by Corning during the war for military radar. In most ways they are like the bulbs Corning is now preparing to make for a television set that may end up in your living room.

And that's why television is nearer than you think! Years ago television in its infancy was the "father" of radar. Today, as a result of development to meet war's urgent needs, radar can more properly be called the parent of tomorrow's television. These bulbs are just one example of how glass developed by Corning for use in war will have an equally important place in peacetime living. The list is long. It includes special "metalized" glass parts for wartime radio and radar equipment. A method of mass-producing high-quality optical glass for the Army and Navy. Glass pipelines and glass pumps that are impervious to chemical attack and outlive other materials. Glass so resistant to thermal shock it can be heated cherry-red and then sprayed with ice water without breaking. All these and many more research achievements establish glass made by Corning as versatile engineering material with ever increasing possibilities. That's why it will pay you to learn all you can about glass now. And remember, too, Corning is an outfit that knows glass. Corning Glass Works, Corning, New York.

CORNING
means
Research in Glass

"counter-etching" with mild acid. This treatment is intended to remove the superficial oxidized film on the zinc. Armour Research Foundation has been experimenting with the effects of a new procedure—that of adding by chemical treatment a corrosion resisting film to a freshly grained plate.

Actual production tests on plates so treated have been run in several litho plants in the Chicago area. While it was a foregone conclusion that corrosion resistance would be beneficial for storage and shipment, these tests have indicated that certain benefits also accrue in plate making and in service on the press. One result has been the formation of superior image dots and, in several runs, a marked reduction of acid required in the water fountain solution was recorded. The full significance of these early tests is being traced.

A consideration of the principal fields of study involved in this investigation, as listed in the center column of Fig. 4, indicates the versatility of experience and knowledge required and again emphasizes the effectiveness of a concerted and coordinated attack on the various phases by numerous specialists, such as afforded by the Armour Plan.

Magnetic Sound Recorder Wire. In addition to sponsoring a research program of several years' duration on fine wire drawing technology, the National-Standard Co., Niles, Mich., is actively cooperating with Armour Research Foundation in the development of an improved wire for the magnetic sound recorder and, to this end, has made very substantial contributions financially and in personnel.

The results of current work with stainless steels indicate that a relatively efficient recording medium is in the process of being developed. The important variables are appreciated and the preparation of wires of different qualities to suit varying requirements seems to be feasible. Efforts to reduce those background noises thought to be inherent in the wire have been quite successful for practically all applications, and further work is being carried on to produce a wire having optimum properties and good uniformity. Accordingly, attention has been centered on metallurgical practices, including the melting, pouring, forging, rolling, wire drawing, and heat treatment of all alloys under consideration.

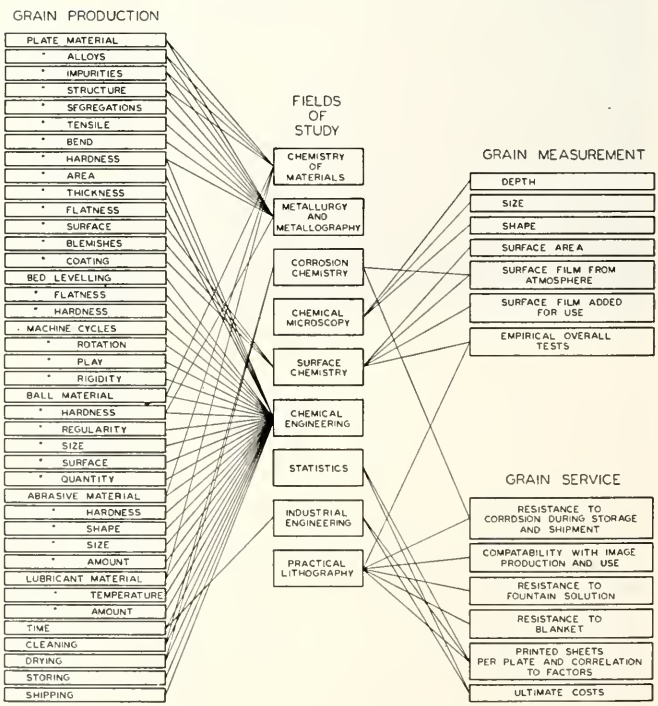
Metal Bellows Behavior. An investigation of the behavior of sealed metal bellows has been in progress for several months. This item is used in a variety of aeronautical devices because it can be made to respond to atmospherical and temperature changes and thus automatically control the function of the unit in which it is installed. Extensive studies of bellows variation have led the investigators into fields of metallurgy, chemistry, electrochemistry, physics, and bacteriology.

Powder Metallurgy. The powder metallurgy laboratory, as previously reported, has done extensive work in producing high strength parts made by powder metal technique and in producing nonferrous articles of predetermined and controllable porosity.

Recently an extensive research program, designed to permit the production of small pieces of exceptional accuracy and unusually intricate shape, has been started. A die which makes a compact of intricate shape containing several tiny holes has been designed, constructed, and placed in operation. A systematic study has been made of the effect of various sintering temperatures on the density of the finished compacts. A precision study of the dimensions of green compacts produced from the same die, both before and after sintering, is in progress.

Precision Casting. During the past year research has been performed on precision casting by the "lost-wax" technique for both ferrous and nonferrous materials. Control has been established on the successful reproduction of a wax pattern from a master die to dimensional tolerance of 0.0002 inch per inch of length. Investi-

Figure 4.
FACTORS IN GRAIN PRODUCTION, MEASUREMENT, SERVICE, AND FIELDS FOR THEIR STUDY



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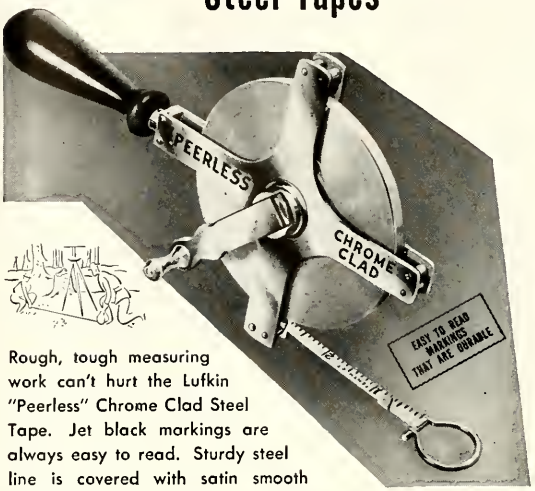
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gations are in progress to determine mold and casting temperatures which will consistently give dimensional tolerance of better than plus or minus 0.0005 inch per inch of length on the final casting.

Slush Pump Liners. The life of slush pump liners can be greatly extended through the proper selection and heat treatment of the steel. This is the basis of a full scale test being made for the Harrisburg Steel Corp. A 5 x 8-inch Wilson-Snyder pump with auxiliary equipment has been installed to simulate conditions existing during oil well drilling and data are to be taken to determine the best materials and treatments to be used for the liners. The results will be translated into oil well drilling economy.

Steel Castings. Research on a new method of casting steel has continued during the past year. The process is now undergoing a rigid testing program to reveal its most suited range in the steel casting field. American Steel Foundries has sponsored this project for four years.

Watch Technology. Studies in the field of watch technology sponsored by the Elgin National Watch Co. have continued. Since the component parts of a watch must be made with the highest precision, the Foundation's work has been concerned with very precise metal processing operations and very precise control of these operations.

White Ware Bodies. A project sponsored by The Cambridge Tile Mfg. Co. has been in progress for the past year to study fundamental properties of bodies and glazes. Petrographic examinations and x-ray diffraction studies are being made to determine the effects of various treatments. In addition, improved firing methods are under study.

Wire Drawing. The National-Standard Co. is beginning the fifth year sponsoring research in fine wire and fine wire drawing technology. Methods of making bakelite casts of the drawing holes of dies have been developed. From these casts accurate measurements are made of the effective elements of wire drawing dies. Statistical studies have been completed on the average life span of diamond and carbide dies. This work has enabled the sponsor to evalnate the various brands of dies now used. A method of inspecting wire drawing dies was devised and standards of design and surface finish were established, which were accepted and employed by several die manufacturers. Die problems of production, design, wear, and failure have been studied. The results of these studies provide a means of control of the factors relating to die efficiency. A diamond die recutting machine has been developed which resizes the wire drawing dies efficiently and accurately. In wire drawing lubrication research, a lubricant has been developed which has been under production testing for more than one year. This lubricant has performed satisfactorily in pro-

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Here is a weapon that beat the Wehrmacht, a cross section view of the submarine "cable" that piped oil from Great Britain to the Allied forces on the European mainland. Paid out from huge coils in the holds of ships, more than 20 flexible pipelines were laid under the English Channel.

As the picture indicates, this "cable" comprises a lead alloy tube, steel reinforcing tapes, steel wire armor and jute wrappings. It's actually a submarine cable except there's no core. Oil flows in the space normally occupied by the electrical conductors.

The Okonite-Callender Cable Company was one of four American wire and cable manufacturers who together turned out 140 nautical miles of this pipeline. Experience in working with others to solve special manufacturing problems is combined at Okonite with years of research and development work in electrical wire and cable improvement. The Okonite Company, Passaic, New Jersey.

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duction applications.

Special Technical Services. The metals and minerals division has aided the Army and Navy Ordnance and numerous manufacturers throughout the country in technical services pertaining to a wide variety of problems in production and control. Immediate attention has been given to war material. Some of the completed assignments are: Carbine Rifle MI-30 caliber studies; certifications of gages used in dimension control of component machine parts; analyses of lime coating materials; engine wear measurements; failure determinations of roller bearings and their correction; corrosion fatigue studies of machine parts used in ammonium nitrate processing equipment; and the preparation of special alloys of particular analyses. The scientific approach to the solution of industrial problems has helped industry to cope with the production pressure of recent years.

Physics Research

More than in any other of the Foundation's major divisions, the facilities and manpower of the physics division have been concentrated during the year on various highly confidential projects for the Federal Government, particularly the U. S. Navy and the OSRD. A gratifying indication of the effectiveness of these developments has been the receipt of a letter of commendation from the Under Secretary of the Navy.

A second major phase of operation in this division has been the emergency production of wire sound recorders for war use. The establishment by the Foundation of a pilot production line for supplying the armed forces with this rugged means of recording was requested by the Government since, initially, no other organization had the technical background to produce the recorders.

As prime contractors for this production, the assembly line was moved from the Foundation buildings to the plant of Utah Radio Products Corp., Chicago, to increase the recorder output. This made it necessary for many of the research personnel to spend full time at the Utah plant in setting up and maintaining the production. As a result, research in the technique of wire recording was somewhat retarded, but the number of recorders made available for Army, Navy, and Lend-Lease requirements was greatly increased.

It may be that full details will not be revealed for some time with respect to many of the ways in which several thousand of these units were employed by the armed forces. At this time, only a few of the uses are known. In both aircraft and naval vessels, recorders were connected to intercommunication systems to provide a complete record of engagements. Also, such installations were used widely for training purposes and the transmission of orders. Other wire recorders on shipboard were incorporated into equipment for evaluating the effectiveness of attacks on enemy submarines. Another phase of training in ocean warfare involved the recording on wire of the underwater sounds made by various vessels. In this manner, sound-detection crews were able to identify the types of

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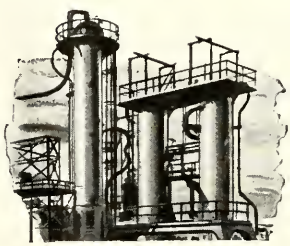


WHAT MAKES STAINLESS STEEL "STAINLESS"?

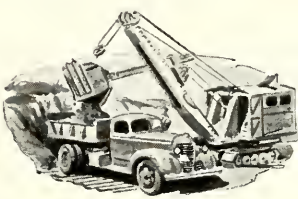
This high-speed train wears a gleaming sheath of steel that's stainless—stainless because of the CHROMIUM it contains. Trains, planes, buses and cars of the future all will be finer still—and lighter, stronger, safer—because of increasing use of chromium in their steels.



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HOW DO REFINERIES STAND THE *"acid test"*?—Highly corrosive acids help refine America's oceans of high octane gasoline. But today's refineries withstand fierce acids, high temperatures and pressures—because CHROMIUM stoutly fortifies their metals.



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Union Carbide does not make or fabricate steel. ELECTRO METALLURGICAL COMPANY and other Units of UCC, however, supply to industry such wonder-working metals as chromium, manganese, and vanadium. With these, and the many other basic raw materials produced by UCC, industry improves a thousand and one products that serve all of us.

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ships in the vicinity.

Reconnaissance aircraft recorded observations on wire, as did advanced land units, and these essentially complete reports aided materially in planning subsequent operations. Also, field staffs recorded entire conferences for review by general headquarters. Battle noises were recorded for certain purposes and newsmen landing with troops on the various beachheads were able to render complete accounts of the action. The wire recorder also served as an effective morale builder for many servicemen and women.

In European underground activities, recorders were effectively employed in transmitting code messages and in obtaining much valuable information from patriots in enemy occupied countries.

At the conclusion of the Foundation's prime contract, additional production for war use had been well established by several of the Armour wire recorder licensees and others operating under the Armour license issued to the Government.

Notwithstanding the requirements of physics personnel for purely production purposes, it has been possible to carry on further research and development in various phases of wire sound recording as detailed in the section describing Foundation-sponsored research.

Automobile Engine Intake Silencer. A project was completed during the past year with the development of a method of recording the noises present in the intake manifold of automobile engines. A magnetic wire sound recorder is used in the car under actual operating conditions on the road. The recorded sounds may then be reproduced in the development shop as often as required to measure the most prominent frequency components. The results of the analysis of the recorded sounds are used in the design of commercial intake silencers for the particular noises prevalent in each new engine model.

Turntables. A study of methods of reducing speed variation and noise in electric phonographs has been made. A better understanding of the causes

of turntable speed variation has resulted in recommendations of design changes for better speed regulation. A measuring system has been developed for determining the components of the low frequency motor vibrations. A knowledge of the source and transmission path of each component has enabled the analysis of methods of reducing the noise.

V-Belts. The Goodyear Tire and Rubber Co. is sponsoring a project for the reduction of V-belt running noise. This noise has been a serious objection to the use of belts where quiet operation is desired. In the program now being started the production and characteristics of the noise will be studied with the object of rendering it inaudible under the worst exciting conditions.

Voltage Regulators. In many devices operated from the usual house or apartment wiring system, variations in the voltage reaching the appliance produce undesirable effects either in performance or length of life. This is particularly true with high power lamps such as are used in home movie projectors. A research program is now being started in which the general field of voltage regulators will be investigated, with particular emphasis upon a vibrating interrupter type of voltage regulator for lamp loads.

Special Testing. The physics division is particularly well equipped to undertake a wide variety of short-term studies and tests and during the fiscal year has rendered the following representative services to numerous manufacturers: x-ray diffraction measurements and analyses of various types of materials, such as enamel films, metal castings, magnetic materials, and food products; spectrochemical analyses of cathode materials, metal ores castings, and forgings; color photomicrographs of plants; development of improved photogrid technique for determining metal flow in tensile strength specimens; particle size determinations by means of electron microscope photographs; spectrophotometric curves of ultraviolet transmission through glass; sound absorption tests on acoustical materials; measurement of the rate of decay of sound from chimes and bells; noise and vibration measurements of blowers, compressors, and forging hammers; determinations of dynamic constants of shock absorbers, Diesel engine mountings, felt materials and neoprene samples; miscellaneous electrical measurements of resistance capacitance, and dielectric strength; and design and testing of radio frequency filters.

Mechanics of Solids Research

Bushings. The fundamental physical properties of rubber are being investigated to establish a rational basis for the redesign of rubber bushings for tank track treads of heavy ordnance vehicles. Special testing machines have been designed and built by the Foundation and tests are being started. The Burgess-Norton Mfg. Co. is sponsoring this project.

Engine Couplings. A program in which the ultimate objective is to find a method of eliminating objectionable vibration from the automotive type of drive system is being sponsored by the Auburn Mfg. Co. A theoretical torsional vibration analysis of a Willys engine has been completed and the power dissipation of standard and experimental hydrodamper clutch units has been measured. Various types of dampers have been designed and the experimental program is being extended to investigate more fully the possibilities of viscous damping.

Engine Vibrations. Calculations of the torsional vibration characteristics of an eight cylinder-four cycle Diesel engine generator set including the natural frequencies, peak amplitudes and stresses, have been completed and a resonance curve of the forced vibration amplitudes has been drawn. Calculations were also made of the corresponding torsional stresses of this engine fitted with a rubber type damper. At present these calculations are being correlated with test results in order to establish a rational basis for damper selection. This project is sponsored by The Buda Co.

Flexible Shafting. The experimental testing of shafts has been completed and the testing equipment which was designed to test fatigue of shafts has been sent to the sponsor, Stow Mfg. Co., for regular testing purposes. Further mathematical analysis will investigate the bending flexibility of shafts in order to determine the pressure exerted by a core enclosed in a curved casing while transmitting torque.

Insecticide Dispenser. During the year a design of a unit for dispensing insecticide fluid under pressure was developed for the Burgess-Norton Mfg. Co.

Switch Operation. An analysis of the Micro Switch BZ-R has been undertaken for Micro Switch Division of First Industrial Corp. to improve the basic working principle of the Micro Switch. The approximate theory now completed will be refined by considering the effects of flexural rigidity of the switch members. Since one of these members is a strut with a type of loading not treated by elementary methods, the investigation will invoke considerable original work. The conclusions may then be applied to all switches using similar structural elements.

Tractor Seat Location. A program sponsored by Deere & Co. deals with the basic motions of a tractor, the determining of the displacement, velocity, and acceleration of any point on a tractor frame as it moves over rough ground. The study at this point is entirely of a theoretical nature. However, there are indications that the theoretical studies should be amplified by actual measurements on a tractor. The basic purpose of this program is to locate the points which have the minimum displacement, velocity, and acceleration disturbances.

Basic Research and Special Testing. The division of mechanics of solids research is also cooperating with Illinois Institute of Technology in supporting the mechanics and aeronautics research laboratory, which provides additional space and equipment for basic research. Special equipment, including a wind tunnel and facilities for instrument development, have been incorporated into this laboratory. During the year, the effects of combined stresses and of low tempera-

tures on the static and fatigue strength of welded and unwelded metals have been investigated and studies of the basic failure mechanisms of wire rope have been made.

In the past year the materials testing laboratory, in addition to standard tests on the strength of materials, has had requests for tests of materials unique in size, shape, or properties. In most instances, methods for performing these special tests have been devised successfully. Facilities are available for determining the strength of a wide variety of materials at temperatures ranging from —100° to +1800° F.

Services of the Navy lightweight impact tester continue to be available to a cooperative group of thirty-one manufacturers for shock testing of electrical ship-borne equipment.

Fluid Mechanics and Thermodynamics Research

Automobile Air Conditioning. A study is being made of the different types of cooling systems with the objective of developing a cooling system for automobile airconditioning equipment.

Fluid Pumps and Motors. A project having as its objective the development of hydraulic and pneumatic pumps and motors of a positive displacement type and a mechanism of radically new principle is being carried out for the Pittsburgh Equitable Meter Co. This is a very comprehensive program requiring the development of an adequate theory to explain the operation of the mechanism, a complete investigation by experimental means of the performance of existing models, and formulation of recommendations leading to improvements in the design.

Theory of Flight. A study of the flight of insects, with a view to developing principles of flight was carried out this year. This work was sponsored by the Operadio Mfg. Co.

Thermocouples. A research program on thermocouples, to investigate their possible use for cooling in place of temperature measurement, is being carried on.

Year-Round Air Conditioning. A study of year-round air conditioning is being made for the Utilities Research Commission. The purpose of the investigation is to review the research work done to date in the field of air conditioning, both electric and gas, particularly the so-called "heat pump," to determine whether the reversed usage of the refrigeration cycle as a source of heat is practicable in the Chicago area. Approximately forty commercial and domestic heat pump systems in the United States have been inspected and studied.

Special Testing. Apart from long-term investigations, the Fluid Mechanics and Thermodynamics Division has undertaken a number of extensive research testing programs and other studies. In the fluid mechanics section these have pertained to studies of ceiling type air diffusors for manufacturers to determine the discharges from the units as functions of anemometer and velometer readings at the outlets and piezometer pressure readings in the approach pipes. Also, studies were made of the amount of flow loss from the supply side directly to the exhaust port in the combined supply and exhaust units.

Examinations and analyses have been made of: a patent and its model of a percussion type drill to determine feasibility of development for oil wells and for earth foundation exploration; relief valves for liquid-petroleum containers in their relations to existing inspection requirements; a dish-washer model for various operating conditions with a variety of nozzle arrangements; and the motions of a bulldozer in traveling over rough ground to determine the effect of the interconnected hydraulic cylinders which raise and lower its blades.

Characteristic curves have been obtained for positive displacement pumps, covering a wide range of viscosities. Blowers have been designed and tested and specifications written for production testing. Of particular importance to manufacturers, but available to industry generally, has been the permanent installation of equipment for determining fluid friction losses in valves and fittings. A large number of valves from ½-inch to 8-inch in diameter have been tested for losses at various positions of the valve disk.

The thermodynamics section has made conductivity measurements on samples of insulating materials for approximately twenty-five different companies. Its varied testing program has included vapor penetration determinations on samples of treated paper; comparative wear tests on rubberized hair samples to select the proper material for carpet pads; determination of the lowest temperature at which boots for certain aircraft equipment are flexible; efficiency tests of a heat exchanger installed in the stack of an oil burner; comparisons to determine the difference in the amount of heat dissipated by aluminum and bronze journal bearings under loads of 10,000 lb.; rating tests on convectors and unit heaters; and studies of the velocity distribution and quantity of air delivered by an electric heater.

Calculations were made to fix the length of time that food would remain hot in containers of various design and to determine the most efficient method of insulating a liquid gas storage tank. The efficiency and output of gas stove burners of different design were measured, together with the carbon monoxide produced and, similarly, the efficiency and output of coal stoves operated under various conditions were found.

Electrical Engineering Research

Calibration. A calibration and testing project was started during the year for the Chicago Zone of the Signal Corps Inspection Agency. The Agency established a mobile calibrating unit to check contractors' equipment in the radio and radar fields. The importance of keeping its own equipment calibrated led the Signal Corps to place this project with the Foundation.

Fractional Horsepower Commutator Motors. A program was carried out attempting to find a better way of connecting enamel insulated armature wires to the commutator segments in order to improve the quality

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of the product and to reduce manufacturing costs.

High Temperature Broiler. An automatic electric broiler was developed which will broil small steaks in less than one minute at high temperatures.

Radio and Radar Transformers. A manufacturer of radio and radar equipment had difficulty in obtaining transformers which were required to be free from internal corona disturbances. Tests were performed for several subcontractors building these transformers and resulted in the obtaining of satisfactory equipment.

Radio Frequency Noise. A test program for the elimination of radio frequency noise originating in motor generator sets was completed for the Continental Electric Co. of Rockford, Ill.

Shielding Conduit. A special test unit for comparison of the shielding effectiveness of flexible shielding conduit was made for the Chicago Metal Hose Corp.

Speed Control. A study is being made of a new form of adjustable speed control for wound-rotor induction motors to determine its practicability for industrial use, particularly for the drive of machine tools.

Strain Gage Equipment. A nine-channel amplitude modulation type of strain gage amplifier for simultaneous recording of nine strain time functions was constructed during the past year. This unit is part of the equipment of the Foundation's mobile stress laboratory. The strain time functions are recorded photographically from a cathode ray oscillograph. This unit is most adaptable to the measurements of low-frequency dynamic strain conditions.

Torque Meter. Tests are under way to develop a new principle whereby static and dynamic torque in shafts can be measured by electronic means.

Transformers. Considerable research investigation has been conducted during the year for a manufacturer of distribution transformers to improve the methods of core assembly and core construction of this type of transformer. The investigation included a study of core impregnating materials and core treatment.

Vacuum Tubes. The electronics section of the electrical engineering division is continuing its study of the effect of shock and vibration on vacuum tubes under the sponsorship of the Navy Department, Bureau of Ships.

Special Tests and Services. Many tests were performed for different sponsors on a wide variety of miscellaneous problems or apparatus including winches, tank axles, electric motors, transformers, and various apparatus, to determine their characteristics and to make recommendations for improvement.

A.C. Network Calculator. Under general supervision of the electrical engineering division is the new A.C. Network Calculator laboratory housing forty feet of metal cabinets in which are incorporated some two hundred electrical circuits. Primarily a device for the study of problems of electric power system design and operation, it replaces extensive and impracticable calculations by direct measurement of voltages, currents, etc., in an actual miniature electrical replica of the system to be studied.

In use, the known operating conditions of a long distance power transmission line, including impedances of all circuits, voltages at various points, power being generated at all generating stations, and the magnitude and power factor of all loads, are matched by calculator values through proper connections of the various circuit elements. The board thus correctly represents the power system, and the effects of changes, such as the addition of new lines, the serving of new loads, the placing of new generators into operation, etc., can be predicted by accurate measurements at all points. Such determinations cannot generally be made in the actual system because measuring equipment is not usually available where necessary for this purpose.

Transient studies can also be made by using a step-by-step process in which the readings of one step are employed to calculate the conditions that must be met on the following step.

In addition to power system studies, the Network Calculator can be used in

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certain complicated problems of mechanical stresses, heat flow, and acoustics by translating the elements into terms of electrical equivalents and studying the resulting electrical system on the board. The possibilities in this direction are still being explored.

The cost of this air-conditioned laboratory, including the board itself, reception room, conference rooms, facilities for making black and white transparencies and prints, and two portable d.c. calculating boards, amounted to approximately $90,000 and was financed through the cooperative action of the Foundation, Illinois Institute of Technology, and the following manufacturers and power companies:

Allis-Chalmers Manufacturing Co., Milwaukee, Wis.
Carnegie-Illinois Steel Corp., Chicago, Ill.
Inland Steel Co., Chicago, Ill.
Interstate Power Co., Dubuque, Ia.
Iowa Electric Light and Power Co., Cedar Rapids, Ia.
Iowa-Illinois Gas and Electric Co., Rock Island, Ill.
Kansas Gas and Electric Co., Wichita, Kans.
Ohio Public Service Co., Cleveland, Ohio
Otter Tail Power Co., Fergus Falls, Minn.
Sargent & Lundy, Chicago, Ill.
The United Light and Power Service Co., Davenport, Ia.
Westinghouse Electric Corp., Pittsburgh, Pa.
Wisconsin Electric Power Co., Milwaukee, Wis.
Wisconsin Gas & Electric Co., Racine, Wis.
Wisconsin Michigan Power Co., Appleton, Wis.
Wisconsin Power and Light Co., Madison, Wis.
Wisconsin Public Service Corp., Green Bay, Wis.

Participating companies purchase time on a unit basis, each unit permitting use of the board for one week each year for twelve years. It is anticipated that time may be available to companies not included in the sponsor group, based upon a fixed fee for each day's use of the laboratory and the services of an experienced operating engineer.

Ohmite Laboratory. Through the generosity of the Ohmite Co. of Chicago, Ill., a laboratory for the precise measurement of electric and magnetic quantities has been established under the joint supervision of the Electrical Engineering Division of the Foundation and the Electrical Engineering Department of Illinois Tech. Intended to afford a needed service to industry, as well as to the various campus institutions, the Ohmite laboratory is now staffed and equipped to offer the following: calibration of standard cells, shunts, standard resistances, d.c. ammeters and d.c. voltmeters; conductivity measurements; calibration of a.c. voltmeters, a.c. ammeters and wattmeters; iron loss measurements

at power frequencies; permeability and B-H curve determinations; measurements of self-inductance, mutual-inductance and capacitance of condensers at frequencies ranging from 60 cycles to 50 megacycles; 60 cycle and 1,000 cycle power factor and dielectric constant determinations of liquid and solid dielectrics; oscillographic studies; and audio- and high-frequency measurements up to 20 megacycles of frequency, inductance, capacitance, distortion, and Q factor. Additional equipment to be received after the first of the year will permit a very large range of resistance measurements with great precision.

Engine and Lubricants Research

Activity in research testing and development of lubricating oils for internal-combustion engines has continued for the fifth year in the Engine Research Laboratory. The installation of additional engines and testing equipment has increased the scope of the services performed for the petroleum industry, chemical manufacturers of petroleum additives, and engine manufacturers. The transfer of oil analysis equipment and personnel to a new laboratory in the engine research section has greatly facilitated the physical and chemical inspections of used oil samples from engine test work. During the year a total of fifty-five petroleum companies and five chemical manufacturers were rendered a testing and evaluation service in connection with the qualification of heavy duty lubricating oils under Ordance Specification 2-104B and of engine preservative oils under specification AXS-934.

The Engine Research Laboratory has cooperated with the Coordinating Research Council in the development of testing techniques. In addition to crankcase lubricant evaluation, this laboratory has conducted research in connection with the improvement of ignition characteristics of Diesel fuels by the addition of certain coal tar derivatives. A service to the petroleum industry has been initiated for the evaluation of universal gear lubricants. This type of compounded lubricant is required in the hypoid rear axle of most vehicles and is highly essential to the satisfactory performance of military vehicles. Army specification 2-105B calls for certain chemical and physical performance tests to be conducted on these lubricants, and the engine research section has made available to industry a chassis dynamometer for the evaluation of these lubricants, on a high speed axle test. In addition, tests for moisture corrosion (Spicer test), storage solubility, foaming, and compatibility can be performed. Armour Research Foundation is rendering a rather unusual service to the Coordinating Research Council and to the industry by purchasing, storing, and distributing reference oils to be used in the standardization and calibration of engine testing equipment, testing procedures and testing materials.

The Engine Research Section is also rendering a professional service to the Ordnance Department in the qualification of heavy duty lubricating oils. Tests on lubricants made in laboratories of the petroleum refiners and chemical manufacturers are submitted to an Ordnance Reviewing Committee which holds meetings at the foundation. This committee reviews the results of the test work and recommends to the Ordnance Department the acceptance or rejection of the various oils. To assist the Ordnance Department in the qualification of these lubricants, complete reports are submitted on each of the oils, including all of the pertinent test data and photographs of the test parts. The test parts, together with the used oil samples, are also made available for inspection.

Diesel Engine Indicators. The study of engine indicators and their possible applications in the diagnosis of operating conditions of compression ignition engines has been continued throughout the year for the Bacharach Industrial Instrument Co. Research on the effect of compression pressures on engine performance has been completed and the information being gathered from these experimental studies is now being used in an attempt to develop standards in the

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use of engine indicators incident to engine maintenance and operation.

Future work will cover studies to determine the effect on firing pressures of engine operating conditions such as fuel pump timing, rate of pressure rise and fuel nozzle conditions.

Engine Wear Tests. An investigation of the relation of lubricating oil filtration to engine wear is being made by Armour Research Foundation for the automotive industry. This work is made possible by a contribution from The Cuno Engineering Corporation. Wear tests made with a heavy duty four cylinder Diesel engine, under normal operating conditions, are showing the effect of filtration variables on such wear factors as piston ring weight loss, ring gap increase and dimensional change, cylinder liner wear, extent of iron and ash contamination of the oil, and removal of iron and ash in the filter.

Partial flow and full flow filtration have been studied, and results evaluated with reference to data from test operation with no oil filter. The development and application of a new, improved method of cylinder wear measurement, and data obtained from studies of the dispersal of elements produced by engine wear throughout the lubricating oil circuit, have aided the development of the exacting technique required to evaluate engine wear.

Special Testing. A few of the tests conducted by the Engine Research laboratory in addition to those normally handled on a fixed-fee basis have included: the calibration of an air-fuel ratio meter operating on the thermal conductivity principle of exhaust gas analysis; a performance test on a small single cylinder two cycle gasoline engine for use by the Navy; an investigation of a multi-fuel carburetor; a complete power and economy and heat-balance test on a 150 h.p. bus engine; a series of engine tests performed under various operating conditions to establish an evaluation procedure for medium-duty or truck and bus oils; and a series of engine tests for the study of supercharging techniques in which a supercharged single cylinder prototype Diesel engine having over twice the b.h.p. output of normal Diesel engines was used.

Foundation-Sponsored Research

In spite of pressure on the entire research staff for the early completion of projects sponsored by industry and the Government, appreciable progress has been made during the year on investigations and studies initiated under the Foundation's own sponsorship. These have for their purpose the development and improvement of research techniques and apparatus, as well as the discovery of new and basic information which can be employed in the solution of industrial problems. This program also embraces research and development on devices which contribute directly to the general public welfare. As a rule, Foundation-sponsored projects are undertaken in fields permitting fullest use of the specialized training of members of the research staff and the equipment available to them, and are distributed among most of the major divisions.

Acoustic Tubes. Minor improvements have been made on both large and small acoustic tubes during the past year to facilitate measurement of coefficients of normal absorption of samples of acoustical materials, especially those having very low values of sound absorption.

Alloy Plating. This project is intended primarily to deal with the theoretical aspects of alloy plating, but may lead to practical results as well. The system which has been investigated thus far is copper-tin. A plating bath has been studied which permits deposition of copper-tin alloys having compositions ranging from pure copper to pure tin. The effects of bath composition, temperature, addition agents, and current density have been studied in some detail. The physical properties, appearance, covering power, and other characteristics of the plate and bath have been noted. It is intended that other systems be investigated similarly.

D.C. Amplifier. The program of research to develop an amplifier having a frequency response of from 0 to 10,000 cps. or greater and without appreciable phase shift continues on a

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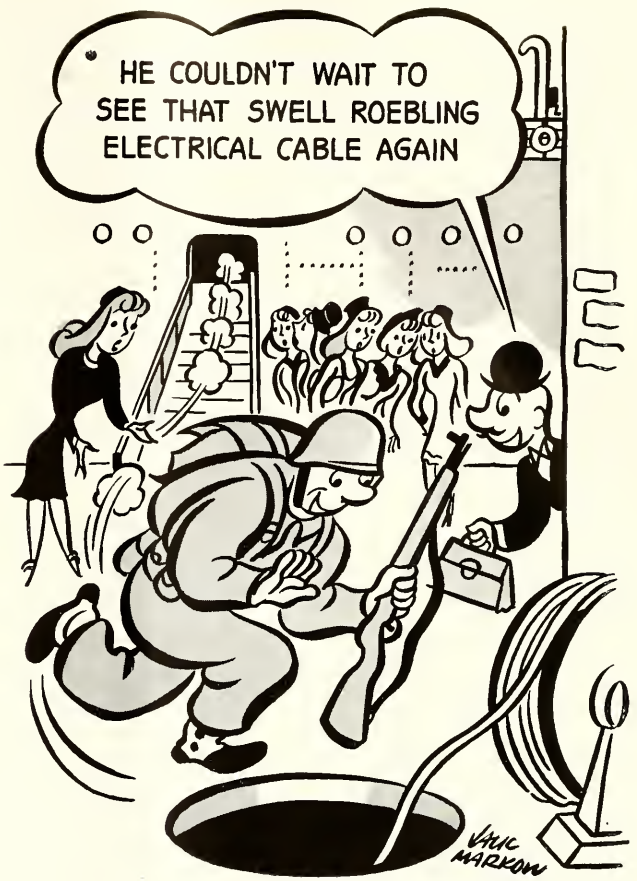
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limited basis. A circuit has been designed in which amplifier stages after the first stage are screen driven rather than control grid driven. This method of operation permits common grounding of all tube cathodes and operation of the control element at a potential above ground. It has the disadvantage of requiring power to drive the screen driven amplifier stages, but it appears that this power can be satisfactorily furnished by means of cathode follower stages between amplifier stages. A two-stage amplifier embodying these principles has been constructed and is ready for tests.

Dielectrics. The rate of deterioration of solid and liquid dielectrics in an inert atmosphere is being investigated at various temperatures in order to deterine whether or not the absence of oxygen prolongs the life of insulating materials. In making the tests, three-mil paper strips are immersed in transformer oil contained in sealed glass tubes about one inch in diameter and six inches long. Oil and paper occupy about 80% of the space and nitrogen fills the remainder. The samples are removed after varying lengths of time. Mechanical strength tests are made on the paper and chemical and electrical tests on the oil. Industrial organizations cooperating with the Foundation in this study include the General Electric, Westinghouse, and Allis-Chalmers Companies.

Electrical Networks. A book, "Tabular Methods for Electrical Network Problems," has been prepared and will be published in 1946.

Characteristically arithmetic and tabular, the methods of this book provide students and practicing engineers with an efficient new tool for use in securing numerical answers to their electrical network problems. When solving for the currents of d.c. network, for example, the usual algebraic network equations are not written. Instead, the emf and resistance values of the network are tabulated according to a prescribed form. Solution then consists in performing with these tabulated quantities a succession of similar, repeated arithmetic operations, resulting in answers. At all times, the forms and procedures employed are especially suited to slide



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rule computations. In problems of equivalent resistance, net-work simplification, and equivalent net-works, the tabular method is more direct and efficient than methods employing wye delta-delta wye transformations and Thevenin's theorem. The proceedures employed for the solution of a.c. net-works avoid the use of complex number operations, yet complex number answers are obtained.

Fluid Mechanics. A textbook on advanced fluid mechanics is being prepared. The treatment generally follows classical lines with special attention being given to applications in aerodynamics. An unusual feature is the full development as application arises of the mathematical topics which, although basic to a thorough understanding of fluid mechanics, ordinarily are beyond the scope of undergraduate engineering curricula.

Hardenability of Steels. Wartime demands of heat treaters, desirous of obtaining the maximum effect on various properties of steel with a minimum of alloy, have been aided by utilization of mathematical and graphical relationships of hardenability "S" curves which are available for almost all of the SAE, NE, and common tool steels. However, the relationships of the "S" curve cannot, on the basis of our present knowledge, be quantitatively applied to quenching and similar treatments in which the temperature is varied. In the Foundation project, the results obtained at constant temperatures are being correlated with those obtained at varying temperatures. From this study it will be possible to predict how rapidly a piece of steel will have to be quenched to develop maximum hardness.

High Pressure. The laboratory for this work is equipped to handle a large variety of studies in high pressure. A press capable of exerting a total force of 1,000,000 lb., with a clearance of zero to five feet between platens, is available. Auxiliary equipment has been in process of construction for studies in compressibility and viscosity of liquids and the solubility of gases in liquids at high pressures. The effects of pressure on the equilibria of some second order reactions are being investigated. The results of a portion of this work will be published in the near future.

Magnetic Wire Sound Recorder. The recorder is fundamentally a medium for converting sound waves into corresponding magnetic impulses and translating them onto a fine wire of suitable composition and uniformity. This is accomplished by passing the wire at a substantially fixed speed through a dual purpose recording-reproducing or sound head. The sound waves entering a microphone are converted into an electric current which is then amplified electronically as in a radio. These electrical impulses set up a magnetic pattern in the wire as the latter passes through the recording-reproducing head.

Music, speed, or supersonic signals may be played back immediately after recording by again passing the wire through the sound head which now acts as a pickup and is energized according to the magnetic pattern in the wire. After again being amplified, the impulses are converted into sound waves by the loud speaker.

Erasure of the recording is effected by means of a high frequency demagnitizing coil, permitting reuse of the same wire for innumerable different recordings, each of which may be played back practically an unlimited number of times with no appreciable loss of fidelity.

A number of technical improvements during the year have permitted the establishment of certain tentative standards under which it is expected that nearly all instruments of this type will employ wire of 0.004 inch in diameter traveling at a uniform speed of 2 feet per second instead of earlier speeds of 2.5 and 5 feet per second. Normal wire consumption has thus been reduced from about 0.5 to approximately 0.2 lb. per hour. It is possible with these standards to make sound recordings with a frequency response flat within $\pm$ 3 db. from 60 to 8,000 cps. and with very low distortion and background noise.

Also tentatively standardized at this time are the dimensions of the spools on which the wire is level wound, enabling them to be interchanged among the various units to be manufactured for many different recording purposes.

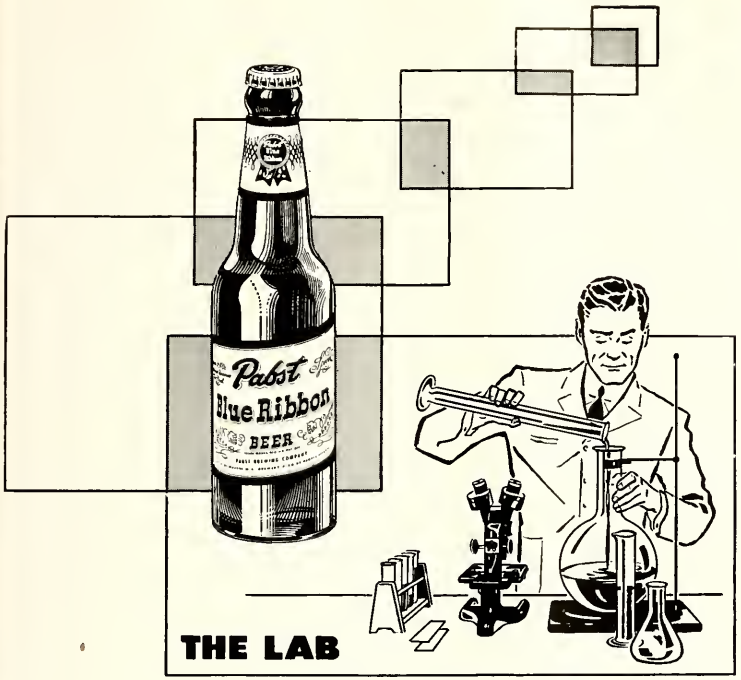
Among other developments has been the construction of a wire tester designed to measure quantitatively the residual magnetism, coercive force, and noise characteristics of recording wire during the process of manufacture. The instrument is now in regular use in the plant of one of the wire producers.

The important phase of multiple duplicating has also received attention during the year. For the purpose of making a large number of duplicate wire records from a single master copy, the Foundation has built experimental equipment employing recording heads, amplifiers, and wire drive mechanisms. It is hoped that ultimately banks of these units can be so arranged as to produce simultaneously practically an unlimited number of copies.

While responsibility for the successful development of all phases of sound recorder research remains with the physics division, numerous important contributions have been made by other Foundation divisions, principally electrical engineering, mechanical engineering, and metallurgical and the machine and instrument shops.

Optical Crystallography. During the past year the mieroscopy group has been accumulating experience and instruments for the determination of optical constants. An extensive investigation of the optical properties of organic compounds has already been initiated with a study of the principal isomers of DDT. The crystalline vitamins are now under study with the aim of determining all of the crystallographic properties (both optical and geometrical with at least some x-ray data) that are useful for identification of the vitamins. These data will be published with similar information on other organic compounds, such as the antibiotics, sulfa-drugs, and enzymes, in the form of annual volumes of the type illustrated by "Organic Syntheses."

Ozone. An investigation of the thermodynamics of ozone production is now on its second year. The influences of water vapor and ozonizer temperature have been studied as a preliminary step before the design and construction of a commercial



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The above determinations are based on the use of air with the ozonizer operating on 60-cycle current. Further gains in efficiency may be made by the use of oxygen and higher frequencies. Investigations are being continued to fix more definitely the optimum oxygen concentration and frequency at which the ozonizer should be operated for the most economical production of ozone for industrial purposes.

Phase Rule Studies. Phase investigation of organic systems is being carried out by fusion methods in order to increase the usefulness of microscopic methods in organic research. Methods for purity determination and identification, together with an improved identity test to replace the customary mixed melting point, have been developed. In addition, the techniques for determining 1- and 2-component phase diagrams by microscopical studies have been improved.

A new hot-cold stage making possible the microscopic examination of systems at temperatures ranging from —50° to +250° C. has been designed and constructed.

Photomicrography. An optical system has been perfected and special film obtained to permit rapid photomicrography of dynamic systems. Rapid phase changes can be recorded with 1/500th second exposures at intervals of one second.

Spectroscopy. The variety of problems arising in spectroscopy has necessitated the development of very general methods and techniques. Semiquantitative methods may be applied to qualitative problems for a quick estimate of the major and minor components of the material. Standards can be prepared for problems requiring rigid quantitative estimates.

Surface Free Energy. Considerable progress has been made during the past year in investigations on the stability (free energy) of different faces of a given crystal. Results of this research will be of importance in the study of grain growth and related phenomena which are evident in metals during annealing or upon long standing.

X-Ray Crystallography. A theoretical study of the vibrational modes and frequencies of quartz oscillator crystals was undertaken, resulting in the development of a theory on the vibration of thin crystal plates. The results of these calculations *(2)* agree with previous observations and it is hoped that this work will contribute to improvements in the design of crystals for high frequency stabilization.

Another investigation was also completed, involving a study of the nature of microscopic distortions and defects resulting from the plastic deformation of metals. Of special interest have been the backgrounds of x-ray patterns of cold worked metals. A general theory has been developed associating distortion with the intensity of the x-ray background as a basis for obtaining further information concerning the mechanism of plastic flow *(3)*.

Staff Additions

Within the fiscal period ending Aug. 31, 1945, 137 new members have been added to the staff as follows: administrative and consulting, 3; physics, 15; metallurgy and minerals, 15; chemistry and chemical engineering, 20; mechanics of solids, 7; electrical engineering, 11; engine research, 4; fluid mechanics and thermodynamics, 5; research services, 23; special services, 4; stenographic and clerical, 16; maintenance, 7; Mexican office, 3; and Wire Recorder Development Corp., 4.

Publications

Publication of the Foundation's quarterly technical news magazine, *The Frontier*, continues as a general public service into the eighth year. Containing articles in the fields of chemistry, physics, and metallurgy, etc., particularly with respect to recent developments. *The Frontier* is mailed without charge to several thousand industrial executives and staff members of research and educational institutions in the United States and foreign countries.

A new booklet by Francis Godwin, "To Our Sponsors," was issued during the year intended primarily for distribution to the Foundation's current and prospective sponsors. Touching upon the philosophy of research, the attitude with which it should be approached and the results to be expected, this 32-page booklet should also be of help to industrial executives whose research programs are not too clearly oriented. The pamphlet also describes the purpose of the Foundation and the manner in which it works with its sponsors. Copies are available upon request.

Of particular interest to manufacturers and other now engaged in or planning to engage in trade with Mexico, is an address analyzing the current financial situation in that country, delivered earlier in the year by the Director-General of Banco de Mexico before the eleventh convention of the Mexican Bankers Association held in Guadalajara. In conjunction with its Mexican technological survey and the Mexican-American Conference on Industrial Research, Armour Research Foundation has obtained an excellent translation of this speech and will mail copies to those interested without obligation.

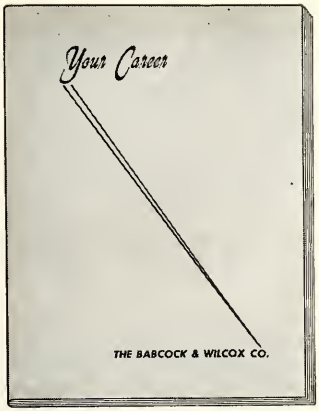
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(3) *Phys. Rev.* (Sept. 1-15).

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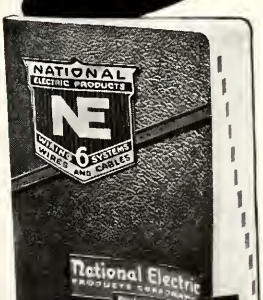
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HEATING

[*Continued from page 13*]

comes the Southeast, despite two exceptionally cold seasons. The Northeast has experienced the least change toward warmer weather.

Figure 1 shows detailed bar graphs for each of the years (centering in winter) 1898-1942 for each of the 10 regions studied by Kincer. The downward bars indicate fewer than the normal number of degree-day units, and hence fewer cool or cold days.

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ENERGY

[*Continued from Page 20*]

tionary process for converting nuclear energy directly into electricity without passing through a heat-power conversion stage. In some way, for example, the kinetic energy of charged sub-atomic particles moving at high speed against an electric field, may be delivered directly as electric current.

General Comments

Today's most important question in the field of nuclear energy is that of atomic weapons. In a few years all large nations will know how to manufacture them in ample quantity. I doubt that any dependable technical defense will be developed. This situation therefore calls for drastic moves in the national and international fields to head off an atomic war that will ruin victor as well as vanquished.

Meanwhile, I would immediately free nuclear research. Tremendous benefits, particularly in biology and medicine, may be expected from these studies, largely through the use of "tagged" atoms (isotopes or artifically radioactive) as tracers.

To achieve these benefits, and thousands of others we cannot yet imagine, nuclear research must have a free hand. When our attention shifts from fundamental laboratory research to the practical details of plants for preparing and applying the fissionable materials, our course, for the next year or two, must depend on the trend of national and international relations.

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FACE LIFTING

[*Continued from Page 10*]

The responsibility is not that of the industrial designer alone, but rests equally with the engineer and the manufacturer: with the builder as well as with the architect.

The work of the industrial designer has been outlined clearly and simply by Morris Sanders, the distinguished



Gas-fired, flue-vented space-heater designed for the Rheem Mfg. Co., Los Angeles, in a variety of colors to better fit into the decorative scheme of any selected room. A special grille at the top directs heat for the greatest efficiency. Designed by Walter Dorwin Teague, N. Y.

Eastern architect in a paragraph from a lecture delivered at Yale University:

"Whether the designer's activity results in handsomer playbills, toothbrushes, or caterpillar tractors, doesn't matter. There is deep satisfaction to be found in raising the standards of understanding and comfort of society. And although, unlike doctors, we artists and designers take no Hippocratic oath, we must consider ourselves duty-bound to render the existences of our fellow-men as agreeable as we can. Those of us who are both determined and gifted may even go further, may distill truth and reveal occasional traces of true beauty."

Du Pont Digest

Items of Interest to Students of Chemistry, Engineering, Physics, and Biology

CHLOROPRENE RUBBER DEVELOPED BY DU PONT

Chemists and Engineers Unite to Produce "Neoprene," Prove Value of Group Research

THE synthesis of rubber was for many years a challenge to the chemists of the world. In 1925 Du Pont chemists undertook to solve the problem, using as their starting point a discovery announced by Dr. J. A. Nieuwland at Notre Dame University in connection with the polymerization of acetylene. The Du Pont research staff modified his process to form a material known as monovinylacetylene and discovered that this, treated with hydrogen chloride gas, produced chloroprene, a chemical previously unknown. Their next discovery was that the polymerization of chloroprene resulted in a rubber-like solid, superior in many respects to natural rubber itself!

Neoprene, as this synthetic rubber is now called, was first placed on the market in 1931. Although more costly than natural rubber, the demand for it grew rapidly. Du Pont engineers were called upon to design and build manufacturing units embodying improved equipment and better production techniques. The result is that today neoprene production is measured in millions of pounds a year, and the price is only slightly higher than that of prewar natural rubber.

The development, the improvement and the large-scale production of neoprene are another tribute to the value of modern, coordinated research. Neoprene is the result of the cooperative efforts of many Du Pont research chemists, engineers and other technical men.

Chemistry extends the mold-free life of baked goods



A hungry world cannot afford to waste bread. Yet until recently millions of pounds of bread were being wasted annually in the United States because of mold. There was a real commercial need for a material that would delay the growth of this food enemy, if only for a day or two. But to meet requirements, this material had to be edible, wholesome, and completely beyond any suspicion of being toxic.

Combined chemical and bacteriological research resulted in the discovery that 0.3% of calcium propionate or sodium propionate in bread would delay the growth of mold for as long as two weeks. In commercial practice, a concentration between 0.1% and 0.2% was found to be sufficient for average conditions.

Calcium and sodium propionates are made from propionic acid, the synthesis of which (from carbon monoxide and ethyl alcohol) is another chapter in the achievements of Du Pont research—and an interesting one. The propionates occur in low concentration in Swiss cheese and other dairy products, as well as in the human body. Hence their consumption in foodstuffs is both natural and safe.

"Mycoban"—as the Du Pont propionates are called—is a shining example of how intensive research solved a problem which long perplexed baking technologists.

More facts about Du Pont—**Listen to "Cavalcade of America," Mondays, 8 PM EST, on NBC**

Questions College Men ask about working with Du Pont

"WILL I CONTINUE TO LEARN AT DU PONT?"

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On-the-job training of new chemists and engineers is supplemented at many Du Pont plants and laboratories by training courses, lectures, and conferences. In 37 laboratory centers—chemical, biological, metallurgical, engineering, physical—new men are continually exposed to the thinking and direction of men who have given cellophane, nylon, polythene, and many other products to America.

DU PONT
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BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

E. I. DU PONT DE NEMOURS & CO. (INC.)
WILMINGTON 98, DELAWARE

NEGLECTED

[*Continued from Page 16*]

grapes being squeezed by a seated figure symbolizes the gastro-intestinal system. The finished product of which is shown running into a sack held open by a small man (the G. I. tract). A cauldron enveloped in flame is used to describe the liver, long considered the hottest organ in the body. All parts in this manikin are sessile, since they are delicately carved from one piece of ivory.

Medical writing from the past contains many references to the use of these figurines in giving instruction on the physiology of pregnancy. One writer relates the story of a young bride (1865) who tells of receiving instruction with others on pregnancy from a lecturer using one of these female ivory manikins for illustration. Another teacher left a note to the effect that he had constructed the figurine so that his students could be better taught than those who commonly practiced midwifery with evil effects because of their ignorance of anatomical parts. And on the other hand, there is ample evidence that an artist often constructed a manikin for his own amusement, or for some wealthy and professionally interested person. Yet one could take more space proving that the carved replicas were constructed for the purpose of teaching anatomy and obstetrics, or develop the thesis that it was a powerful artistic drive that prompted their construction, and not make the point that a few minutes' careful examination of the illustrations will make.

NOTE

[*Continued from pages 18-19*]

Figure 1—When Uranium 235 undergoes fission the loss of mass is converted into energy according to Einstein's law.

Figure 2—In principle the complex arrangements of piles and chemical-treating plants at Hanford, Wash., boils down to the fundamentals pictured. At Hanford the piles are operated to make plutonium, while the heat (in cooling water) is wasted. If and when atomic energy is applied commercially the pile will be operated primarily for the heat released.

Figure 3—The nuclear binding energies of all the elements are here plotted in billions of B.T.U. per pound. These are computed as follows: Add the separate precise weights of the protons and neutrons in the nucleus. Subtract the precise weight of the nucleus. The difference is mass per atom converted into "binding energy". This, divided by the atom's mass, is the mass shrinkage in pound per pound. Multiplied by the Einstein constant of 39 trillion B.T.U. per pound of matter, this gives the binding energy in B.T.U. per pound.

Note that the chart is oversimplified for convenience in understanding.

Any nuclear change involving an upward movement on the chart *releases* energy. Any downward change *absorbs* energy. The energy released or absorbed per pound is simply the change in ordinate.

MARSH & McLENNAN

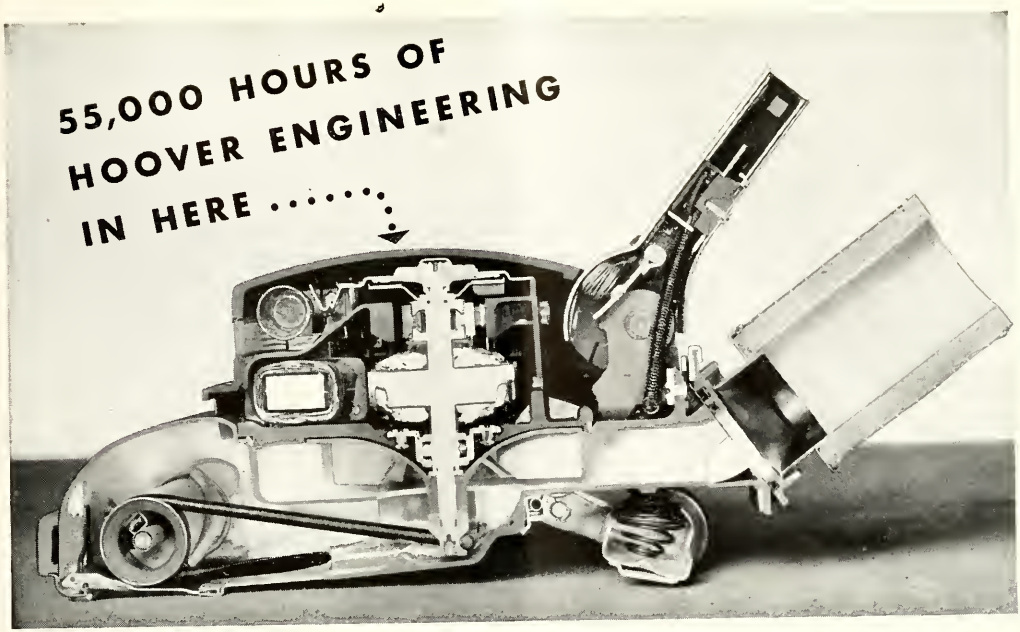
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Established 1871



There's a heap of engineering in a Hoover electric cleaner.

A typical model shown in cross section above required 55,000 hours of engineering research, study, and work to get it ready for production.

This is a fair average figure for new Hoover models.

The Hoover Company has been the world's largest manufacturer of home cleaners for nearly forty years. To maintain leadership, and be first with the latest and the best, Hoover requires the full-time service of an engineering staff of 130 . . . at least a third of them graduate engineers.

This modern four-story brick building, totaling 60,000 square feet of floor space and containing up-to-date laboratory equipment, is the Hoover Engineering Department.

The Hoover Cleaner is "born" in the development engineering division, where teamworking skilled designers, inventors and engineers plan tomorrow's electric cleaners.



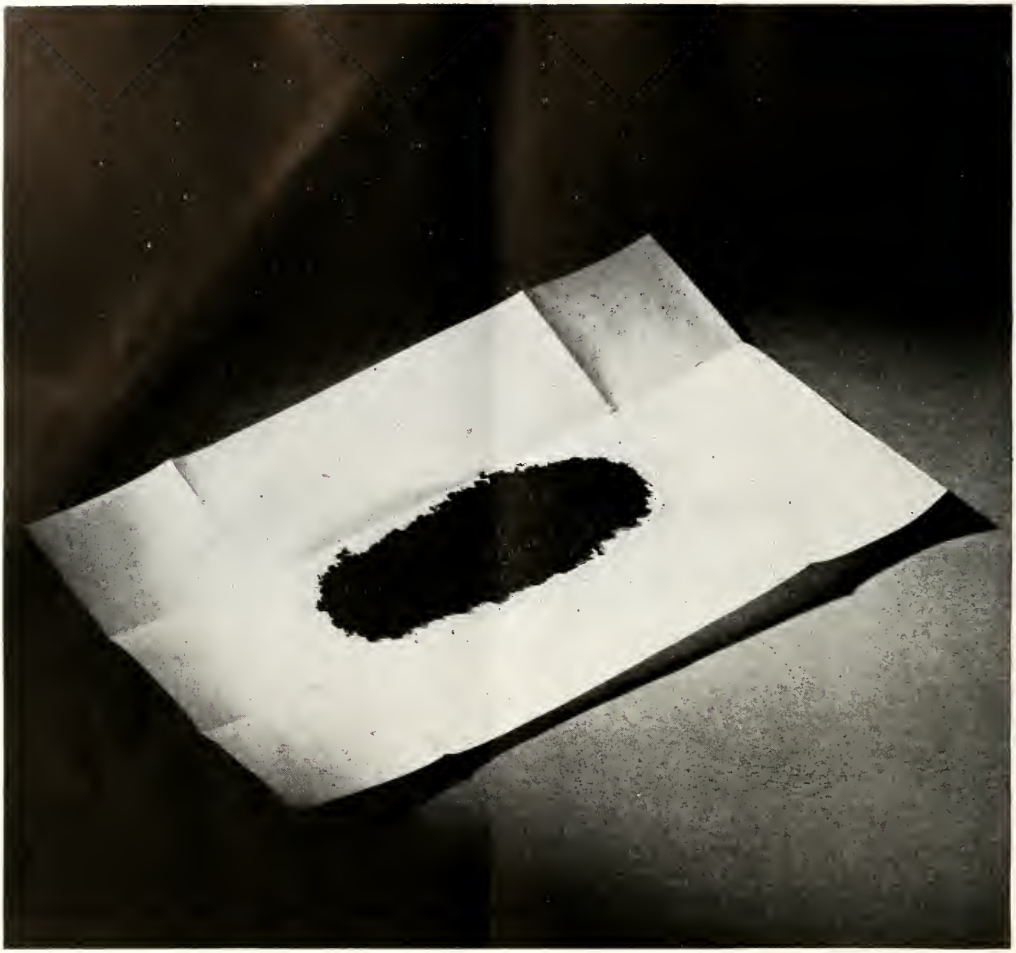
The laboratory division studies and tests, rejects or recommends each component part of each new product "to be."

Mechanical engineers measure noise and vibration, design fan systems, study cleaning methods and solve power transmission problems in developing new designs.

Electrical engineers develop and test motors, wiring, switches, lamps, etc., designing the right power plant and accessories for a Hoover.

Product engineers solve manufacturing problems, set up standards, see that Hoover quality is maintained.

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Headache powder for industrialists

SEE this powder?

When formed under heat and pressure, it becomes *the hardest metal made by man*, CARBOLOY CEMENTED CARBIDE.

And Carboloy is doing more to help relieve production headaches in metal-working industries *than any other single factor in existence today.*

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Carboloy tools and dies will cut, form or draw modern tough or abrasive alloys *with accuracy and at speeds never before thought possible.*

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This amazing metal *commonly triples the output of both machines and men.*

Carboloy is considered by authorities to be *one of the ten most important industrial developments of the past decade.* For example, it is being used in ever-increasing amounts to wear-proof parts subject to extreme abrasion.

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Throw this challenge back at us!

It's 10 to 1 our field engineers or research men can find ways for you to cut metal-working costs *and* increase the quality of your products with the use of Carboloy. Get in touch with us today.

Carboloy Company, Inc., Detroit 32, Mich.

CARBOLOY

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The Hardest Metal Made by Man



MAIN STREET'S RAINBOW *glows at night*

The glow that brightens night-time Main Street owes its sparkle and brilliance to rare gases that exist in the air we breathe. Neon, argon, krypton and helium used in so-called "neon-tube" signs create a range of colors that pale the rainbow—a brilliance that vies with the sun.

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WHO IS THE LOVELIEST LADY YOU KNOW?

YOUR SWEETHEART? Your sister? Is she someone you know well . . . or someone glimpsed fleetingly in a crowd? Is she blonde or brunette or titian? A movie star, perhaps?

Whoever she is, the chances are that a little black lump of coal has helped to make her beautiful!

For these days, many of her cosmetics contain derivatives from coal—in colorful dyes and delicate fragrances. Lipstick to harmonize with her coloring. Tinted face powder. Rouge. Eye-shadow. Nail polish.

Helping to create beauty is just one of the jobs coal does. Derivatives from coal also are helping to cure the sick, to grow better garden crops, to make plastics, paints, lacquers, to drive airplanes and stoke blast furnaces. In fact, you'd have to search long and hard to find a more versatile performer than a little lump of coal.

For a long time now, Koppers chemists have been studying coal, experimenting with it, making useful chemicals from it. And today, Koppers is producing, in commercial quantities, scores of chemicals for manufacturers to use in finished products of all kinds.

In addition to having a thorough knowledge of the chemistry of coal, Koppers also designs and builds coke ovens, treats wood with preservatives, manufactures piston rings, couplings, airplane propellers, roofing and paving materials, and engages in numerous other activities besides. That's why Koppers is known as "the industry that serves all industry". Koppers Company, Inc., Pittsburgh 19, Pa.

The industry that serves all industry . . . KOPPERS

Straight talk about your after-college job

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AS ENGINEERS OURSELVES, we have found that an engineer starting on his first job is aiming for a great deal more in future years than comfort and security for his family.

He wants, and is entitled to *recognition* for himself, his profession and his achievements.

Naturally, a good place to look for assurance that your ability will be recognized is in a company made up largely of engineers. Who else would place so high a value on engineering achievement?

The Timken Roller Bearing Company is such an organization.

Its products, tapered roller bearings, alloy steels and rock bits, require continuous engineering in their manufacture and in their application to hundreds of other products.

■ Most of our executives are engineers. The company in large measure owes its success to engineers. And engineers will have much to do with its future.

That is why our company, each year, is interested in hiring promising students from the country's leading engineering schools. It also explains why we have so much to offer the men selected.

As trainees come in, no effort is made to shape square pegs into round holes. We know that men fresh from universities often possess valuable latent abilities, unknown even to themselves.

■ So we operate a "Work-as-You-Learn" Plan to discover what a man can do best. There are no classes—no theory. Many months may pass before we are satisfied that a man has found himself and is ready for a permanent assignment to work for which he is particularly fitted. But when that time comes, steady advancement usually follows. Besides aptitude, he then brings to his job a broad practical knowledge of our business.

If our plan appeals to you as a sound way to start your career, we would be happy to talk with you in person. We are particularly interested in men who are working for degrees in Metallurgy, Mechanical, Chemical, Mining or Electrical Engineering. Address The Timken Roller Bearing Company, Canton 6, Ohio.

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2. Tapered Roller Bearing Design
3. Industrial Application Engineering
4. Automotive Application Engineering
5. Railway Application Engineering
6. Alloy Steel Production and Sales
7. Purchasing Department
8. Field Engineering Service
9. Sales Order Department
10. Sales Engineering in Field

FOR STEEL AND TUBE DIVISION

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2. Steel Rolling Mills
3. Heat Treating (Canton Plant)
4. Bar Finishing and Inspection
5. Tube Finishing, Heat Treating and Inspection
6. Stainless Steel Forge Shop
7. Tool Steel Mill and Forge Shop
8. Production Scheduling Department
9. Metallurgical Laboratory
10. Metallurgical Service (Customer Contacts)

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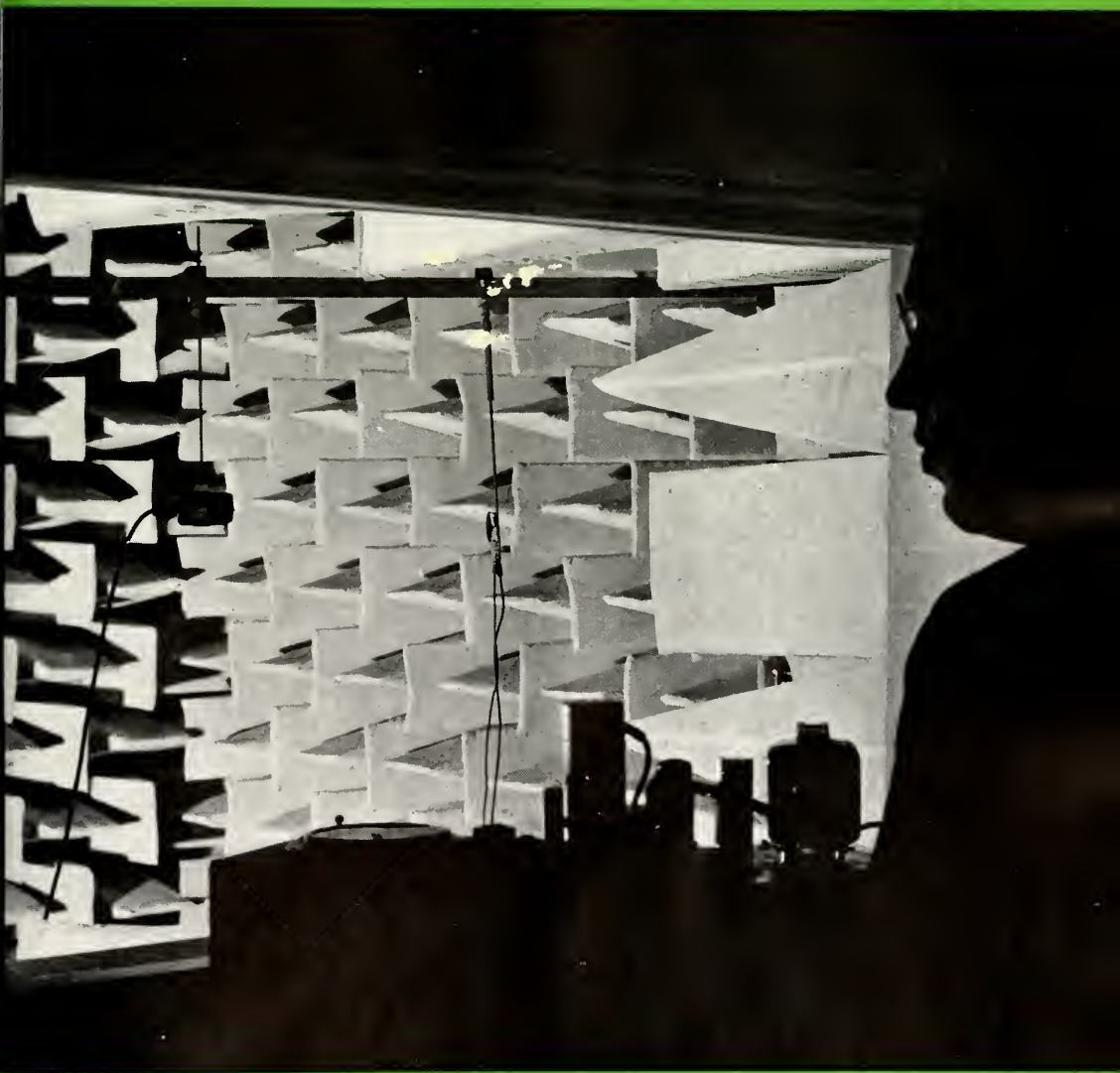
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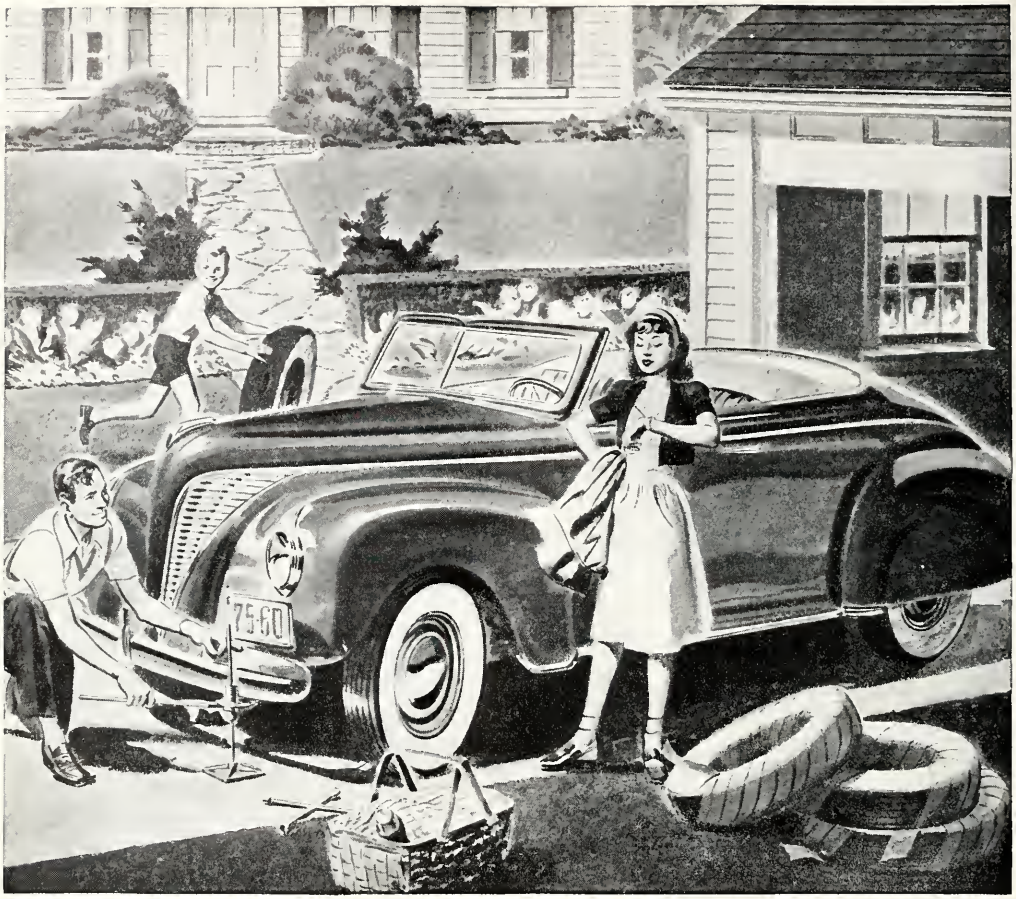


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ILLINOIS TECH ENGINEER



SUMMER, 1946



Quick Change For The Better

Remember when changing to new tires was just another chore? Today it's a pleasure, for it means freedom from that ever-present worry which has plagued all of us whose tires have been living on borrowed time during these past few years.

It's an additional pleasure also to know that these new tires are improved tires, superior in many important respects to those of prewar days. Advances in the quality of natural rubber tires, as well as synthetics, are constantly being made, thanks to the untiring efforts of the rubber industry and the industries that supply it with working materials. Witco Chemical Company has made many outstanding contributions in the form of specially engineered carbon blacks which impart new and desirable properties. For example, a special furnace type black produced by Witco gives added strength and reduces the tendency of synthetic rubber to overheat in heavy duty tires. Other Witco blacks, engineered to meet manufacturers' special processing requirements are helping to provide the exact degrees of tensile strength, elasticity, abrasion resistance, tear resistance and other qualities necessary for endurance and long tire life, not only in tires but other rubber products. In addition, Witco's research laboratories are constantly striving to advance the standards of a variety of products in which carbon black is used . . . such as paints, printing inks, paper, plastics, leather, linoleum, polishes.

This service in carbon black is part of Witco's expanding service in chemicals, oils, pigments and asphalts. A new booklet giving interesting information on fundamental properties of various Witco blacks will be sent to you on request.

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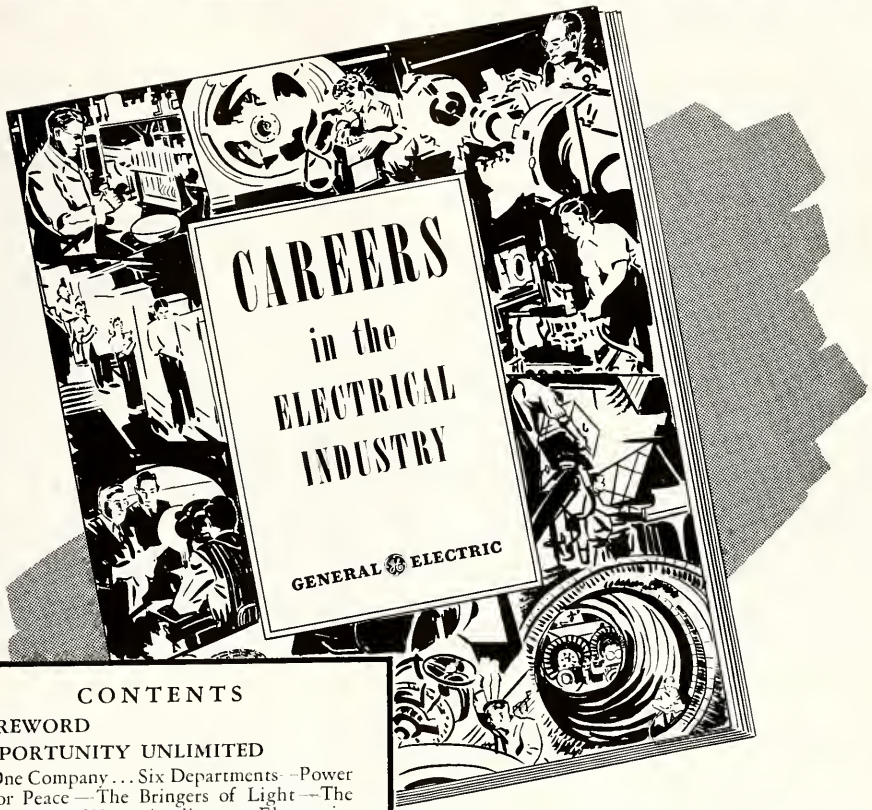
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Campus News

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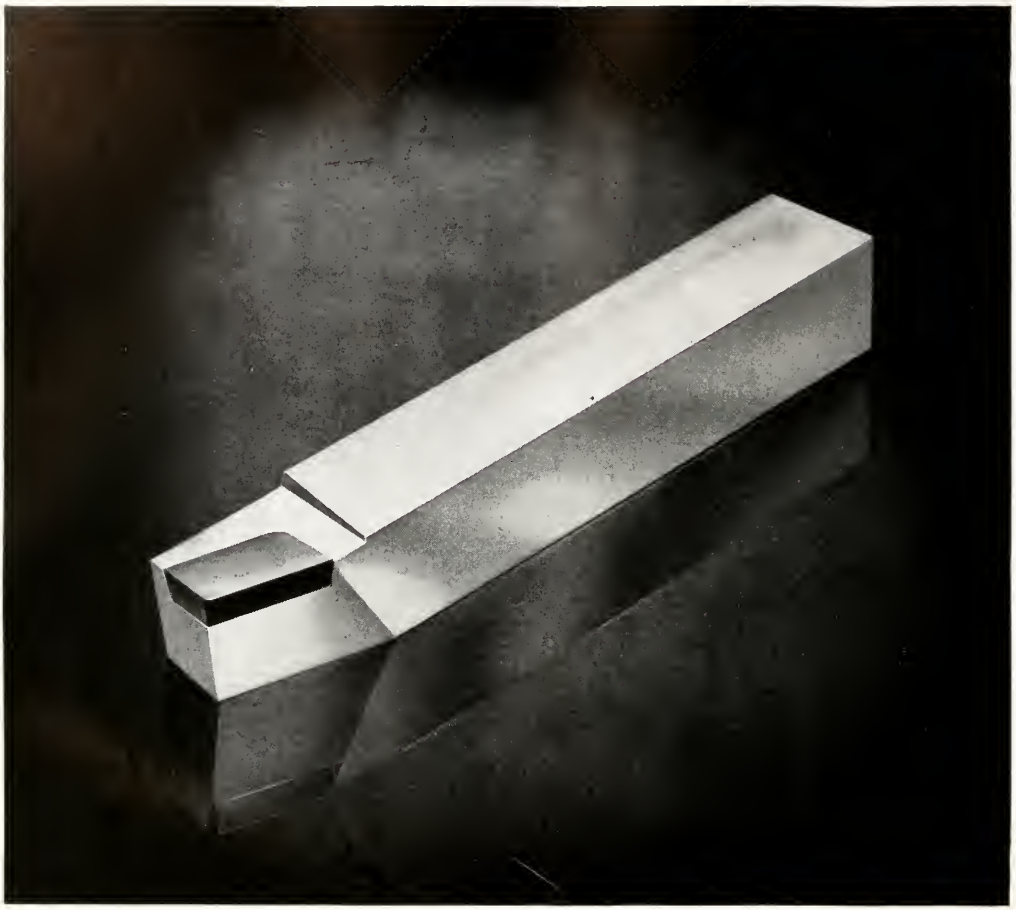
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WHAT are *your* symptoms, Mr. Executive?

Do you have enlargement of the labor payroll? Are your material costs painfully high? Is competitive pressure hard on your balance sheet?

Then perhaps your production lines need a major operation . . . with *one of the most amazing production instruments in existence today*—Carboloy Cemented Carbide.

Don't take our word for it. Take these facts!

Fact No. 1 — Carboloy Cemented Carbide cutting tools and dies will cut, form or draw the toughest alloys *with accuracy and at speeds never before thought possible.*

Fact No. 2 — Today, *more metal is being removed at higher speeds* with cemented carbide than with any other material.

Fact No. 3 — Carboloy tools and dies *commonly triple the output of both machines and men.*

Fact No. 4 — A locomotive builder said recently that he could *cut his production cost 50% if he could re-tool to use Carboloy* all the way along the line!

Fact No. 5 — Carboloy Cemented Carbide is being used in large quantities *to wearproof parts subject to extreme abrasion.*

Fact No. 6 — Carboloy is considered by authorities to be *one of the ten most important industrial developments* of the past decade.

Will you accept this Challenge?

It's 10 to 1 that our field engineers or research men can find ways for you to cut metal-working costs and increase the quality of your products with the use of Carboloy. Write us today.

Carboloy Company, Inc., Detroit 32, Mich.

CARBOLOY

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The Hardest Metal Made by Man

CONTRIBUTORS AND CREDITS

Cover Picture: A camera view by chief photographer Walter Lawton of Illinois Tech's Armour Research Foundation looking into the famous "anechoic" chamber at Parmly Foundation of Illinois Institute of Technology. A sound engineer is pictured recording frequency response measurements.

Designed and constructed under the supervision of Professor Peter J. Mills, Illinois Tech Physics Department, the chamber is modeled on a similar one built by Dr. Leo L. Baranek at Harvard University. Lined on six sides with a total of 2,500 fiber glass wedges enclosed in canvas "stockings", the arrangement is designed to absorb all noise. To permit the movement of instruments, the room is floored with an iron grill.

Purpose of the sound-proof chamber is to eliminate as much extraneous sound as possible so that those originating within the room can be accurately measured by electronic instruments. To that end the sound chamber, measuring eighteen feet in width, twenty feet in length, and twelve feet in depth, rests its forty tons of weight on neoprene pads placed on concrete piers placed within another insulated room. For the comfort of the research worker the room is scientifically ventilated.

It hoped that with the aid of the new sound chamber research will uncover new, heretofore untried methods of preventing and alleviating human deafness.

Dr. Alfred C. Ames joined the staff of the Illinois Tech Department of English as an instructor in 1944. On September 1, 1946, his appointment to an Assistant Professorship becomes effective.

Dr. Ames is a graduate of the University of Kansas; he then took his master and doctorate degrees from the University of Illinois, afterwards teaching at Illinois until he joined Illinois Tech.

Dr. Pearce Davis is Chairman of the Illinois Tech Department of Business and Economics, having been ap-

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ILLINOIS TECH ENGINEER

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WAYNE D. ADAMSON, JR., *Editor*

THELMA L. COLEMAN, *Business Manager*

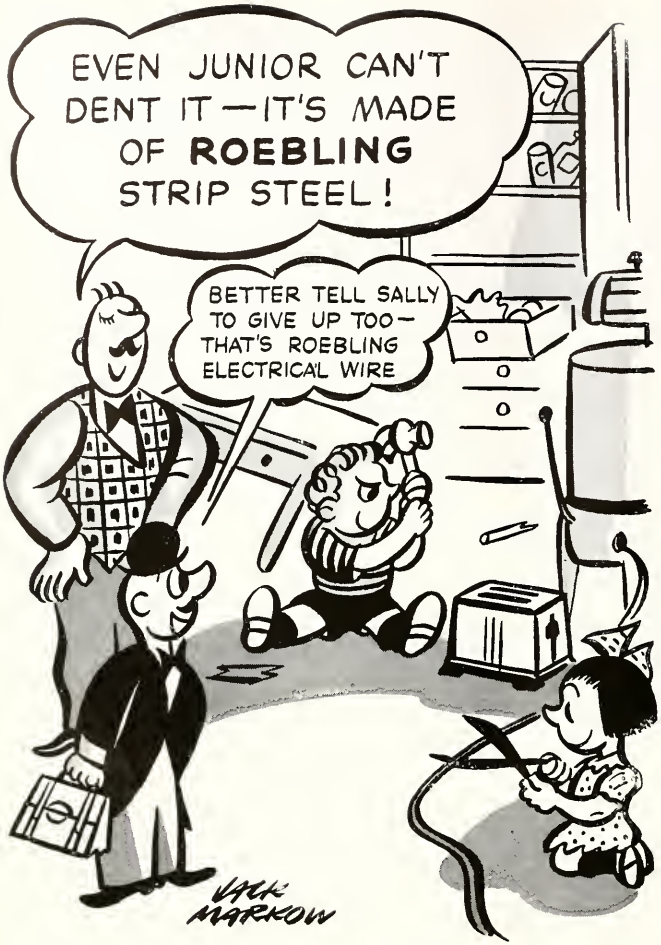
ALUMNI SECTION

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HARRY P. RICHTER, C.E. '32, *Associate Editor*

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pointed early this year. He is a graduate of the Warton School of Finance at the University of Pennsylvania.

Dr. Davis taught at both George Washington and Harvard Universities, and, later, at Hunter College. In 1943 he became Assistant Wage Stabilization Director on the War Labor Board. In January, 1945, he was named head of the Telephone Commission, the chairmanship of which he held until the termination of the War Labor Board's activities.

Dr. Haldon A. Leedy is Chairman of Physics Research at Illinois Tech's Armour Research Foundation. He is also President of the Greater Chicago Noise Reduction Council, the work of which is one of his main interests.

Dr. Leedy is a graduate of North Central College, later taking his master and doctorate degrees in physics from the University of Illinois, where he held an assistantship from 1933 to 1938. He joined the Foundation in 1938.

Herbert Levy is Chief Engineer for the Ohmite Manufacturing Company, Chicago, with whom he became associated in 1933.

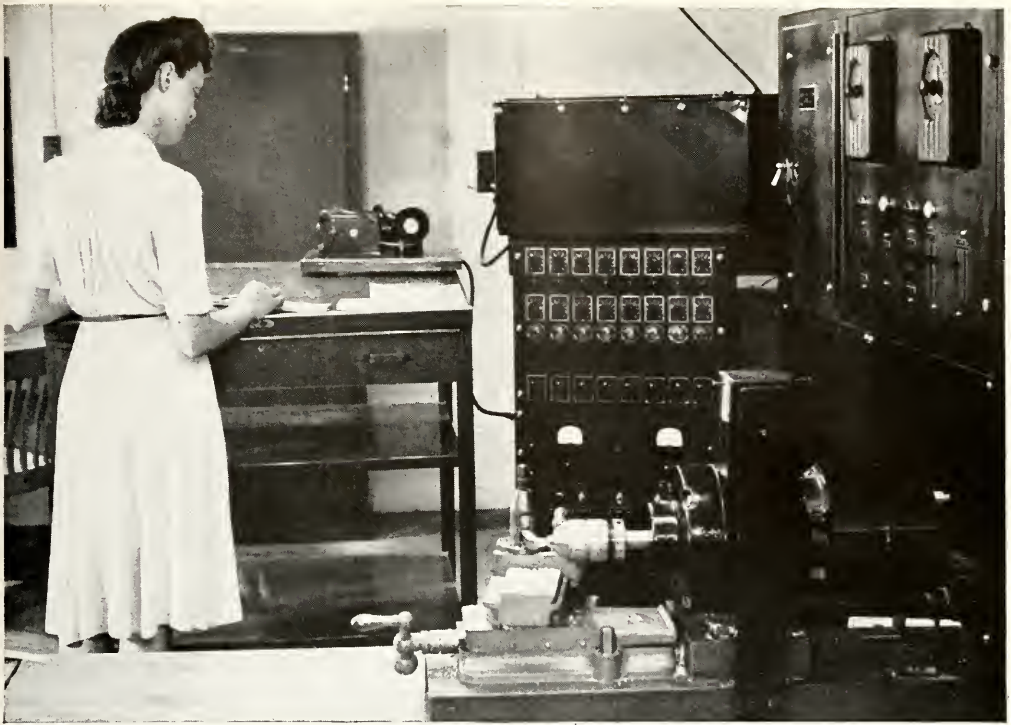
He is a graduate of the University of Illinois, College of Engineering, Class of 1929, with a degree in Electrical Engineering. Before he joined Ohmite, Mr. Levy was with the Delta Star Electric Company as outdoor substation designer. He had previously been a technical writer for the Automatic Electric Corporation of Chicago.

Emmet J. Lowry, Supervisor, Department of Art and Design, for the Research Foundation, is a promotional advertising and product design consultant.

Completing his formal design study at Chicago's Institute of Art, Mr. Lowry operated his own point-of-sale advertising display firm for four years previous to his wartime activities with the Link Belt Ordnance Company.

L. W. Matsch is Supervisor of Power and Electrical Measurements for the Research Foundation and Chairman of the Advisory Committee of Ohmite Laboratory.

See CONTRIBUTORS on Page 6



Typical of its laboratory activities, Dow recently developed this direct-reading spectrometer that electronically measures concentration of elements in alloys—automatically records analyses in 40 seconds.

Horizons of Chemistry constantly beckon . . .

Dow is deeply interested in colleges and technical schools and maintains close ties with them. The very nature of our business makes this a logical course for us to pursue.

We are producers of chemicals essential to industry and agriculture. We are developers of plastic materials. We are the pioneer producers of magnesium, recovering this lightest of all structural metals from ocean water. We are developers of magnesium alloys and methods for their fabrication.

To carry on this work, research is a necessity and a considerable portion of our efforts and resources are devoted to it as an undeviating policy.

All these activities require trained men—scientists and technicians—chemists and chemical engineers—metallurgists, biologists, physicists, entomologists. Dow employs such men in large numbers—keeps an eye on them as they emerge from their academic training—gives many of them special schooling at the Dow plants, according to the jobs they are slated to do.

In peace as well as in war, chemistry is an essential occupation because it deals with materials essential to industry and to the health of the nation. It is a developing business with horizons that constantly beckon—a profession to intrigue any ambitious young man with an eye to the future.

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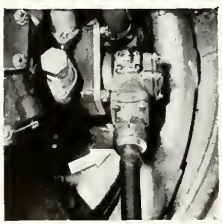
CHEMICALS INDISPENSABLE TO INDUSTRY AND AGRICULTURE

S.S.WHITE FLEXIBLE SHAFTS

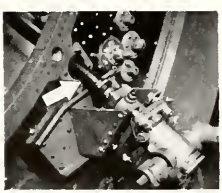
"Metal Muscles" for Power and Control



They simplify manufacturing and cut production costs



A typical S.S.White power drive flexible shaft application — aircraft fuel pump drive. Above—the geared take-off of the shaft from the engine, and below — the connection to the pump. Aircraft applications of S.S.White flexible shafts total millions of feet annually.



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CONTRIBUTORS AND CREDITS

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Previous to his association with the Foundation whose staff he joined in 1940 as Supervisor of the Engine Research Section, Mr. Penfold was service engineer for the Republic Flow Meters Company. He had previously served in the same capacity for the Autogas Corporation.

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In addition to several years of industrial experience as consultant to numerous gas companies, Captain Pettyjohn has completed research projects on the use of bituminous cokes, evaporation, and heat transfer. He was Associate Professor of Chemical Engineering at the University of Michigan at the time he joined the armed forces in 1940.

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Mr. Singh was a member of the Experimental Engineering staff at the University of Illinois for ten years, leaving to join the Foundation's Chemical Engineering staff. In January, 1943, he was appointed to a position at the Institute of Gas Technology.

See CONTRIBUTORS on Page 34

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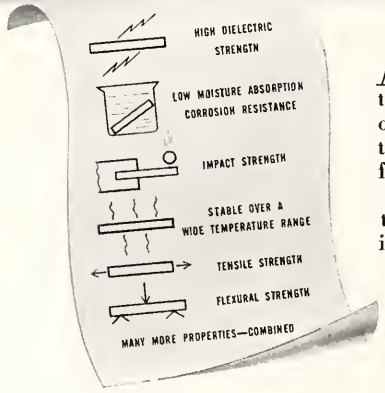
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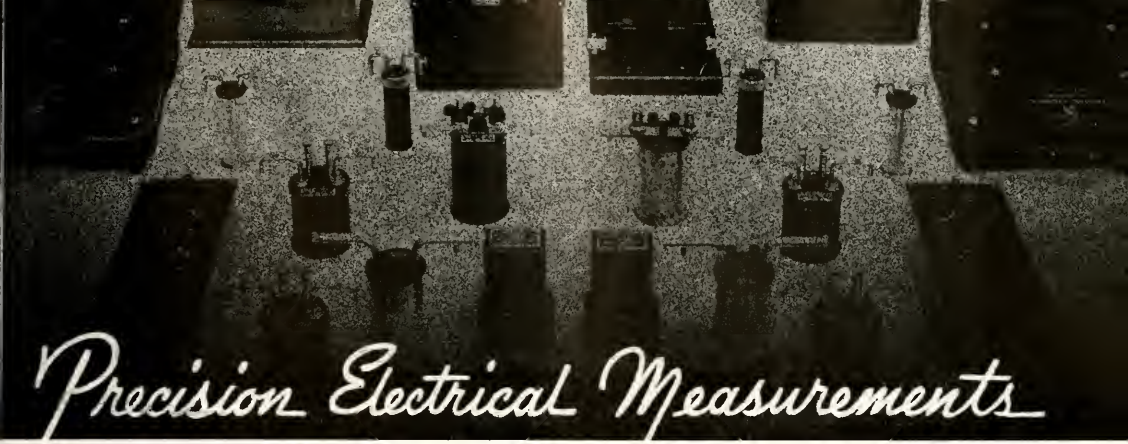
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SYNTHANE

SYNTHANE CORPORATION OAKS, PENNSYLVANIA



at Illinois Tech's

Ohmite Laboratory

BY

L. W. MATSCH

and

HERBERT LEVY

ILLINOIS INSTITUTE OF TECHNOLOGY, with the establishment of the new Ohmite Laboratory as the eighth adjunct of its Armour Research Foundation, is today able to offer still another service to industry, that of precision electrical measurements. At the same time it is adhering closely to the dictates of the modern trends in engineering education.

One of those modern trends is to bring the engineering schools into closer contact with industry. In order to effect this vital contact, a large number of engineering colleges and universities have enlarged their facilities and activities in the field of industrial research.

It was in keeping with this trend that Illinois Institute of Technology organized its Armour Research Foundation in 1936. The original Foundation research staff consisted of but three members, today it numbers four hundred. With a total business of $30,000 at the end of its first year of operation, Armour Research reported $1,901,346 at the end of its ninth year, 1945. In that it is organized as a nonprofit corporation, all excess of income over expense is reinvested in plant, equipment, and research.

Illinois Institute of Technology, through the medium of the Research Foundation, offers a unique research service to industry—reportedly spending more than a quarter of a billion dollars for such services each year—and provides the college with a strong industrial background. Moreover, it also offers a service to mankind, in that the underlying philosophy motivating all Foundation research is that it must ultimately result in public benefit.

It was to further these aims that a new scientific laboratory was dedicated on June 18, 1946, in the Engineering Research Building of Armour Research Foundation, located at Federal and 34th Streets on the campus of Illinois Institute of Technology.

Known as the Ohmite Laboratory, the new understaking will provide industry with a precision electrical measurement service heretofore unobtainable in the Chicago area. An appropriation of $35,000 by Illinois Tech alumnus, David T. Siegel, A. S. '25, founder and President of the Ohmite Manufacturing Company, Chicago, manufacturer of electrical equipment, was the means of making the Laboratory possible.

The objectives of the Ohmite Laboratory are to provide a service to industry in the field of precision electrical measurements of a quality approaching that of the U. S. Bureau of Standards, and obtainable only with rare and expensive instruments; to make available precision equipment for graduate study in the field of electrical measurements; and to supply electrical standardization facilities for the various departments of Illinois Institute of Technology. It is not the purpose of the Laboratory to compete with existing commercial laboratories, but rather, to provide a service not generally available in the midwest.



ABOVE: (1) Seen working at a repair job, this expert instrument maker and repair man capable of constructing special measuring equipment when needed is a permanent member of the staff.

The work of equipping the Ohmite Laboratory was started in January, 1945. Orders were placed with leading manufacturers of precision electrical measuring apparatus, while special equipment not available on the market was put into construction in the shops of Armour Research Foundation. The major part of the installations were in place for the dedication ceremonies on June 18.

As it is now equipped, the Laboratory has facilities for: (1) dielectric constant and power factor measurements on insulating materials; (2) measurement of properties of magnetic materials; (3) audio-frequency and radio-frequency measurements, including frequency checks, field strength determinations up to 20 megacycles and the determination of Q, and antenna impedance; (4) calibration of standard cells, standard resistances, shunts, inductors, capacitors, direct- and alternating-current instruments; (5) conductivity measurements; and (6) oscillographic recordings.

With these facilities accurate measurments of all important quantities encountered in the electrical field are possible. For example, studies of dielectric properties and power factors of insulating materials are of paramount importance to manufacturers and designers of capacitors; the permeability and eddy current losses in iron are factors the transformer engineer considers; determination of the Q and radiation resistance of an antenna can be of especial interest to television and FM broadcasting stations whose antennas must work efficiently over wide ranges of the radio spectrum. A laboratory equipped to calibrate standard cells, resistances, and other standards, as is the Ohmite Laboratory, can be of primary importance to manufacturers interested in setting up and maintaining semi-precision laboratories of their own. The Ohmite Laboratory can do the original calibrating and periodic checking of the standards used in these laboratories. Measurement of conductivity of materials aids in producing better raw materials for resistor manufacturers; finally, examination of electrical wave forms by means of oscillographic recordings can be used in designing components for transmission lines. These few examples of the possibilities of the Ohmite Laboratory,

BELOW: (2) Equipment designed and built in the Laboratory set up to make power factor and dielectric constant measurements of liquid dielectrics, accuracies of $\pm 0.01\%$ are possible in this arrangement.



while extremely broad in scope, are only the beginning of what its facilities will eventually allow.

Basic standards of the Ohmite Laboratory are formed from standard resistors and standard cells, each certified by the National Bureau of Standards. At present there are twenty standards of resistance ranging from 0.0001 ohm to 10,000 ohms used for calibration of such equipment as ammeters or voltmeters. In addition there are a number of decade resistance boxes including shielded AC resistors and megohm boxes, useful wherever variable precision resistance is needed. In the Laboratory too is a volt box for increasing the useful range of the potentiometers pictured in Figure Three. Nine variable inductometers provide a continuous range of self-inductance from seven microhenries to six henries. Precision adjustable capacitors cover a continuous range of capacitance from 25 micromicrofarads to one microfarad. A part of this equipment is visible in Figure Four, a general view of the Laboratory.

The equipment listed above will allow the setting up of many types of direct and alternating current bridges in addition to those bridges already on hand. Precision alternating current bridges are of particular importance because of their inherent sensitiveness to stray fields and unbalance to ground. The highly refined equipment available in the Laboratory allows these unknown strays to be accurately taken into account. Of particular interest is the wide ranges attainable in the apparatus; ranges which preclude the possibility of ever reaching a point where practical measurements cannot be made.

A precision Potentiometer set-up for calibrating standard voltmeters and ammeters is displayed in Figure Three. The small scale divisions of the Potentiometer are 0.5 microvolt apart and a reading can be estimated down to 0.1 microvolt. In Figure Six is shown

BELOW: (3) Precision Potentiometer apparatus set up for calibration work at D-C and power frequencies. Two mobile units are used to house current and voltable sources, both variable in a wide range of values.



a precision Wheatstone bridge, the resistance coils of which have been aged for ten years and are immersed in a temperature controlled oil bath. The accuracy of this bridge is $\pm 0.01\%$ for values down to 5 ohms. A Kelvin double bridge which will measure values below 5 ohms with similar accuracy is in transit at this writing.

Equipment for measuring dielectric power factor and dielectric constant of insulting material is exhibited in Figure Two. Measurements of power factor to an accuracy of $\pm 0.01\%$ are being made. With the arrangement shown in Figure Six, the capacitance range is from approximately 50 micromicrofarads to 0.05 microfarads. The range, however, can be extended to larger capacities. A cathode ray oscilloscope is used as a null-detector which, except for the effects of higher harmonics, shows a straight line when the circuit is balanced.

Crystal controlled to an accuracy of 5 cycles in 10 million is the primary frequency standard being demonstrated in Figure Five as the girl adjusts her watch to read correctly. The 24 hour clock at the top of the equipment is driven by a 1,000 cycle motor and indicates time to within .01 second. It is utilized to calibrate frequency of oscillators and of radio transmitters. Four fundamental frequencies; namely, 100, 1,000, 10,000, and 50,000 cycles per second, may be obtained directly. A similar panel of frequency measuring equipment for use with the frequency standard is a part of the apparatus, but is not shown in Figure Three. A portable secondary standard is available for frequency measurements in the audio- and radio-frequency range to an accuracy of ± 0.001 per cent. Oscillographs, oscilloscopes, Q-meters, impedance bridges, radio frequency bridges, and other audio- and radio-frequency equipment are included.

In this application the cathode ray oscilloscope is used in obtaining precision balances impossible by any other method. Adjustments so fine that moving a lead out of place in the setup will disturb the balance may be attained. Unavoidably, the presence of harmonics of the frequency source used mar the usefulness of the oscilloscope on critical measurements. This objection is overcome by an experienced operator who watches only the magnitude of the fundamental trace and ignores all spurious deflections.

The design of important components found in the home radio is furthered by examinations made possible by the equipment described above. Television engineering and the rapid opening up of parts of the radio spectrum considered untenable only a few short years ago have fostered a demand for increased measurement facilities of a precision nature.

A Fahy permeameter and a fluxmeter for use in determining the magnetic properties of materials are installed. In use also is an Epstein core loss apparatus for ascertaining power consumption of transformer iron.

The equipment on hand represents about three fourths of the $35,000 appropriation, the remainder of which will be invested in additional facilities to further increase the scope of the Laboratory's work. Quality of all equipment is maintained by a precision instrument maker, who is a member of the permanent staff. and who constructs special measuring tools as they are required. He is pictured at work in Figure One.

Although the Ohmite Laboratory has not yet been used in the educational program of Illinois Institute of Technology, it is expected that it will be used for many of the graduate courses in the field of electrical measurements. The Laboratory offers great educational values from several aspects. For one, the student will have an opportunity to get the feel of working with commercial precision measuring apparatus. Further, he will develop some of the *patience* required for accurate measurement work, gain an appreciation of fine measuring apparatus, as well as an understanding of the limitations of different measuring devices so that proper selection of apparatus can be made for each particular measurement problem. With such preparation the young engineer should be more at home in a commercial laboratory or, if he does not choose laboratory research as a career, he will be better able to interpret data obtained by others.

In keeping with the policies of the Research Foundation, the educational activities of the Ohmite Laboratory

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TOP: (4) A general view of the air-conditioned Laboratory showing instrument cabinets and a part of the general testing panel where convenient connections to sources of power may be made.

CENTER: (5) This crystal-controlled Primary Frequency Standard is the nucleus of apparatus used for frequency calibrations. Equipment built in the Laboratory supplies multiples of frequencies produced by the Standard.

BOTTOM: (6) Built to the order of the Ohmite Laboratory, the six dial Wheatstone bridge has resistance coils immersed in a temperature controlled oil bath and is used for the determination of electrical resistance.

Should Humanistic-Social Study

BE MADE

Engineering Education?

BY DR. ALFRED C. AMES

WHAT IS "ENGINEERING EDUCATION"? To some the phrase signifies an education in subject matter and in methods peculiar to, or at least especially characteristic of, engineers. To others, "engineering education" means the education of persons aspiring to become engineers.

Before we can consider whether or not humanistic and social studies should be made "engineering education," it is needful to define that last term. We need to ascertain (1) what is peculiar to engineering, and (2) whether "engineering education" means education peculiar to engineering, or education of prospective engineers.

The Engineering Method

We hear occasionally of "engineering ways of thought," "the engineering method," and even viewing literature, music, and art through "engineering eyes." Just how "engineering eyes" focused on literature differ from the eyes of other human beings I do not pretend to know, but Professor Elliot Smith in an article which appeared in the October, 1945, issue of the *Journal of Engineering Education* has defined "the engineering method" as consisting of four stages: defining the problem, planning the treatment, executing the plan, and checking the work. Doubtless that is the engineering method—and also the method of problem solving in *any* field of human intellectual activity. It is simply the standard heuristic method, and may be found conveniently stated and developed in the end papers of Gyorgy Polya's recent book, *How to Solve It*. So far as I can see, there is nothing distinctively engineering about this method.

Thomas Henry Huxley, that great champion of scientific education, began his most famous essay, "*The Method of Scientific Investigation*," with the unequivocal and modest statement, "The method of scientific investigation is nothing but the expression of the necessary mode of working of the human mind." He proceeded to assure his lay audience that they daily employed deductive and inductive reasoning. Is the scientist or engineer entitled to claim as exclusively his own the operations of common sense and right reason? Would it not be as becoming for a teacher of English composition to tell a teacher of mechanical engineering that he should use "the rhetorical method," the "writer's ways of thought," in his engineering work, as it is for a engineer to exhort an English teacher to use "engineering methods"?

If by engineering education is meant *distinctively* engineering education, let us honestly exclude therefrom all logic, all literature, all basic language skills, all fundamental concepts in the social sciences, all mathematics and other "pure" science. If we are to proceed on the premise that only material pertinent to engineers and also not pertinent to other collegiate students is to have a place in our curricula, we shall have to exclude everything that differentiates a college of engineering from an unabashed trade school. What is distinctively engineering and irrelevant to other pursuits and functions is more limited than some people are willing to admit. One cannot make a college curriculum out of it.

If "engineering education" means education of prospective engineers, the criterion of relevance must be not applicability to exclusively engineering functions, but value to persons whose profession is to be engineering. Let the champions of a thoroughly distinctively engineering education admit they do not have a monopoly on sound reason, by all means. Let them recognize further that their prospective engineer has a private life and a civic life as well as a strictly professional life to lead, and that the two former even have some bearing on the last. If this recognition were forthcoming, we should hear no more aggressive demands that every non-technical teacher of engineering students must show a peculiarly "engineering" value for every aspect of his subject.

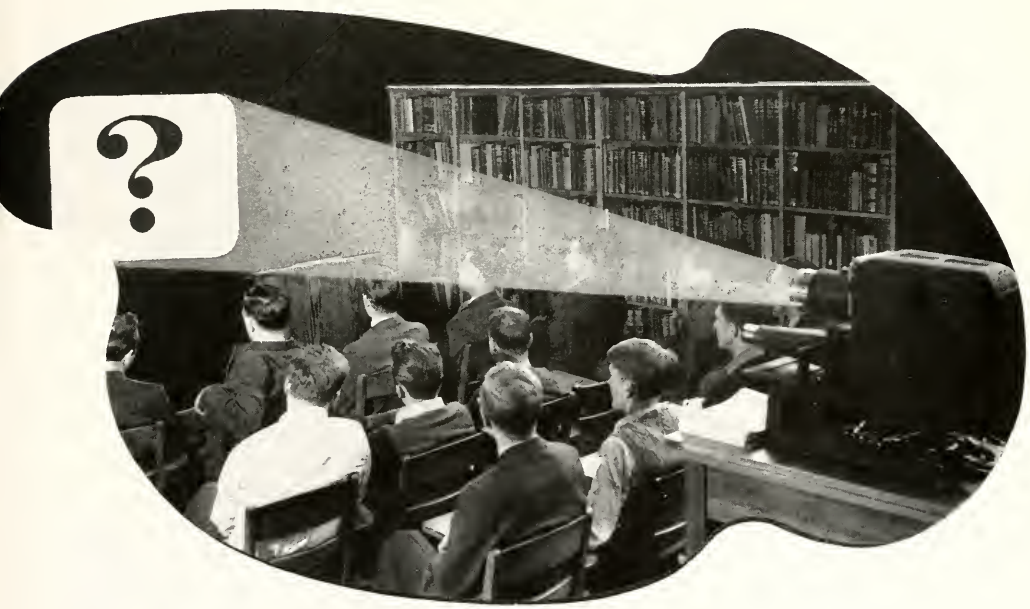
As a matter of fact, it is the champion of a rigorously distinct "engineering education" who perhaps has most occasion to show cause why he should not be censured. If he has his way, what will be his effect on the education of engineers—on students, on faculties, on administrations, on society? In so far as he now has his way, what effect is he having?

The Engineering Student

The engineering student is not necessarily a monomaniac devoid of any interest other than a narrowly defined engineering education. He is, after all, a human being. If you prick him, he will bleed. Usually, he is young, in the late teens or early twenties. Often he has an unusually alert mind. He is still discovering the world, especially the world of ideas and intellectual and moral values. He does not want to be immured in a narrow cell of peculiarly "engineering" education. When a senior engineering student in a state university says, as I have heard one say, "I know less about nearly everything (except electrical engineering) than I did when I entered college," he is not boasting. He is voicing a justifiable grievance.

Even if the students should demand nothing but intense specialization, even if more than a few had these severely limited aptitudes and interests sometimes falsely attributed to all, should they be humored? Just this week an engineering student told me he was planning to leave college at the end of his freshman year and take night school courses in mathematics and electrical engineering, his only vital interests. As a candidate for a degree, he complained, he was being coerced into taking chemistry and, next year, physics! Will anyone maintain we should adjust curricula to such partial personalities, be they one or many? Fortunately for everyone, they are, I believe, few. With continuing sound educational policies, their number can be further diminished.

We who are professionally engaged in the education of engineers should have a more mature and enlightened conception of suitable education than can be expected of our undergraduates. As is characteristic of the human method of determining causes of effects, we are obliged to proceed in our educational plans by elimination of irrelevancies. As causes favorable to the development of self-respecting, reasonably well developed human beings practicing the engineering profession, we can eliminate, I believe, a course of study that produces satiety—a muscle-bound "engineering" intellect that balks at the thought of engineering. We can eliminate a course of study that, so far as it is able, isolates the student from art, music, literature, awareness of the past, political insight, and social concern, except as these may be capable of exploitation for vocational advantage. We can eliminate the wrenching of the course of study into a discipline that inculcates and encourages contempt for and ignorance of studies and interests that are not peculiarly "engineering education." Every moment that is given to non-essential, peripheral tricks of a trade is stolen outright from time that should be dedicated to the end of all higher education: the progressively thorough introduction of the student to important accumulated human knowledge and skill and insight, and the progressively thorough liberation of the student from clumsiness and ignorance and error.



See EDUCATION on Page 58

CITY NOISE

WHAT IT COSTS IN HEALTH

BY DR. HALDON A. LEEDY



ABOVE: Sound level meter used in measuring the intensities of noise as recorded in the graph below which covers a typical day at one of Chicago's busy intersections.

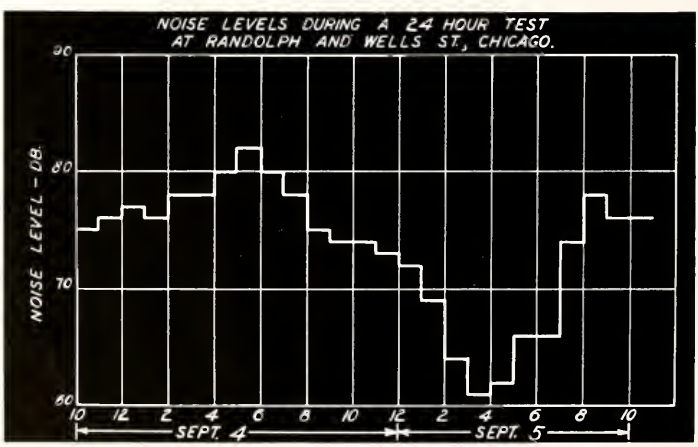
A CITY IS WHAT IT IS because of what every man and woman who lives in that city contributes to it, be that contribution good or bad. We can now, every one of us, make a personal contribution to the benefit of our city. In making this contribution we will, directly and indirectly, increase our personal efficiency and reduce our personal cost of living.

Noise, is costing us money every day. It decreases our income by lowering our efficiency, increases our taxes and our bills for medical attention. In addition to the direct cost, noise brings in its wake other indirect costs which we pay not in money but in "that tired feeling" and in tight nerves. If you are always tired and always have heavy medical expenses, it is more than possible that you are a victim of one of our most pernicious enemies, noise. Noise is a major enemy and this is proven by modern medical findings.

We never completely adjust our minds or nerves to noise. No matter how familiar sound becomes, it is never passed unheard. Every sound registers on our minds and while we sort out irrelevant sounds and ignore them, they still register. Even when we sleep, sound registers on our minds and causes unnecessary activity. Some sounds, which experience has taught us require action—automobile horns and the like—actually result in unnecessary physical activity although we remain asleep. Such sounds cause jumping, leg or arm movement and tossing, all of which means loss of real rest.

No matter how absorbed we become, sound registers on our minds. Our minds work harder than necessary. The result of this is that when we complete a job, we are closer to a state of exhaustion because of increased effort. These things would be serious enough if they were the *only* results of unnecessary noise. If the noise resulted *only* in lowered personal efficiency, we could almost

See CITY NOISE on Page 54



INSTITUTE
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GAS TECHNOLOGY

Carbonization and Gasification RESEARCH ACTIVITIES

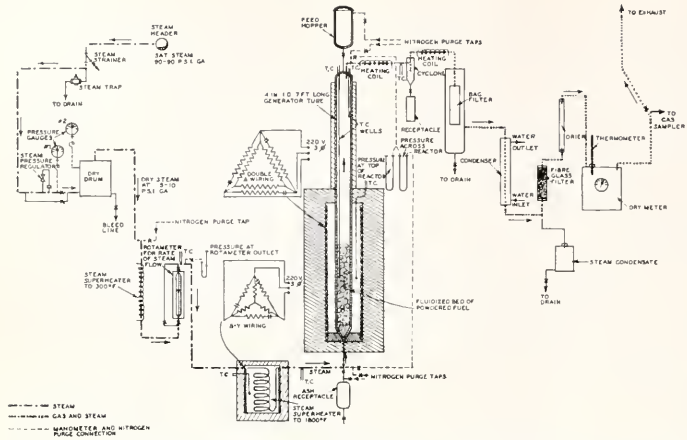
By CAPTAIN ELMORE S. PETTYJOHN, USNR

THE RESEARCH ACTIVITIES of the Institute of Gas Technology are predicated upon the needs of the gas industry and are influenced by the relative importance of immediate necessity and of long-range planning. In its final analysis, the basic source of raw material for gas making purposes will be solid fuel, and will require the upgrading of off-grade fuels either through pretreatment, partial devolatilization and carbonization, or gasification with or without the use of oxygen and pressure with catalytic upgrading of the gases produced, or combinations of these procedures. In the immediate present an ever increasing demand for gas for domestic and industrial purposes require that every potential source of gas or of gas making materials be utilized with the utmost flexibility and efficiency. The relationship of the Institute of Gas Technology's research activities to the solution of these problems may best be understood by a brief review of projects recently completed, in progress, or in preparation.

To meet the rapidly rising peak load accompanying the sale of gas for house heating in both natural, manufactured and mixed gas distributing areas, a study of the utilization of natural gas condensates for peak loads and standby purposes was made in 1944-45 for the Post War Planning Committee of the American Gas Association.[1] This study was followed by a survey on the thermal and catalytic cracking of natural gas and natural gas condensates to gases of lower heating value in 1945-46.[2] Due in part to this stimulus equipment manufacturers and gas company representatives have studied the requirements of specific locations and propane-air, propane-butane-air and butane-air plants have been or are being installed at this time. These plants do not necessarily represent the optimum in cost, flexibility, or operating characteristic but do provide a partial solution for a very pressing problem.

Additional work is planned on the catalytic conversion of low volatile hydrocarbons as carrier gases for propane and butane as one phase of the study of "Sulfur Resistant Catalysts" for the Gas Production Research Committee of the American Gas Association. The successful completion of this work will permit the substitution of carbon monoxide and hydrogen for air in propane-air mixtures with a lowering of the specific gravity and heating value of the substitute gas, an increase in interchangeability, especially in manufactured and mixed gas distributing areas, and decreases in material storage costs and in the operating problems inherent in the addition of large amounts of oxygen to send-out gases.

A second approach has been a study of the hydrate or solvate storage of natural gas and natural gas condensation. A survey of the literature and of patents on natural gas hydrates is being carried forward at the present time for the Natural Gas Research Committee of the American Gas Association and a preliminary study of propane hydrates prepared as a Master's thesis has recently been pub-



Flow chart of generator and auxiliaries used for gasification of fluidized powdered fuels.

lished.[3] Under certain conditions of temperature and pressure, 160-180 cubic feet of natural gas may be stored as hydrate per cubic foot of volume. The relative volumes per volume which may be stored as solvate have not been determined. There are definite advantages and disadvantages in hydrate storage which must be resolved for each specific location and which must be weighed against the problems encountered in liquid and in underground storage to determine the usefulness of this procedure.

An alternate approach would be in the production of "low-cost" blue gas with catalytic upgrading or methanation or the production of "low-cost" hydrogen and the direct hydrogenation of coal to methane. The study of catalysts for methanation and for hydrogen production by the water gas shift reaction are two additional phases of the study of "Sulfur Resistant Catalysts" previously mentioned. Either of these approaches will require the development of new processes, as presently accepted blue gas manufacturing methods require relatively high cost plants and quality fuels. The application of the "fluid" technique to gasification has been studied at the Institute for the past three years and has resulted in several projects which have been carried at least as far as the exploratory stage.

The first of these applications of the "fluid" technique has been in the gasification of bituminous coal using a combination of superheated steam and external heating. The unpublished results are extremely interesting in that both the rates of reaction and the percent of steam decomposed are very favorable. This study is to be continued on a accelerated scale using fines and dusts with and without oxygen.

The second of these applications has been in a preliminary study of the gasification of heavy oil with the possible admixture of coal fines or coke breeze using "fluidized" solids as the heat carrying medium, and will require a determination of physical characteristics at gasification temperatures of the heat carrying solids to be used. The Institute has submitted a proposal for this study to the Gas Production Research Committee of the American Gas Association.

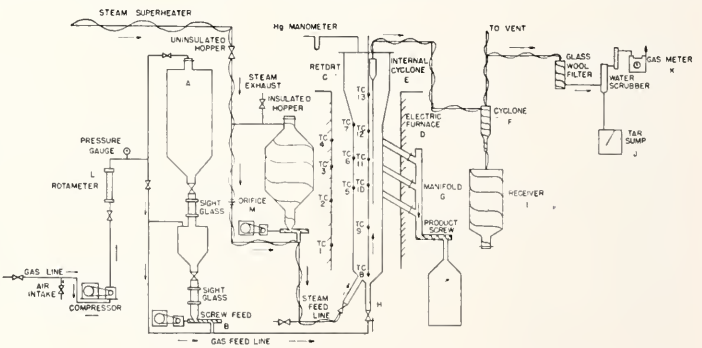
The third application has been in the direct hydrogenation of bituminous coal fines in the "fluid" state at atmospheric pressure and at distillation temperatures. This study has only been carried into the preliminary stages and will require much additional work. Here again the results are promising but inconclusive.

The above applications have been looking toward partial or complete gasification and are of more potential importance to the gas industry.

A fourth application, the partial devolatilization of high volatile coals sponsored independently by the Inland Steel Company and the Illinois Coal Products Commission to produce mid-volatile or low-volatile coals as substitutes for Pocahontas has greater potential value to the by-product coke industry. This partial devolatilization in the "fluid" state has permitted both accurate control of temperature and time at temperature. The by-product gas obtained has been high in heating value, from 780 to 820 B.T.U.'s per cubic foot and the tar a primary tar high in phenolic and cresylic constituents. Coke produced from blends of high volatile and partially devolatilized coals in a special retort at the Institute has compared favorably with coke produced from standard mixes. Tests with Elkhorn coal showed no

See RESEARCH on Page 36

Detailed flow diagram of char making process employed at the Gas Institute for research.



Radiant Heating



FIGURE 4

TRANSVERSE SECTION OF HOLLOW TILE FLOOR WITH PIPE COIL IN CEILING AND PLASTER COVERING

BY T. NAPIER ADLAM

PREPARED FOR PRESENTATION AT THE MIDWEST POWER CONFER
CHICAGO, APRIL 3-4-5, 1946

SINCE THE PRINCIPLES of radiant heating are in many respects directly opposed to the present theory of heating and air conditioning, it is advisable, first, to explain the difference rather than to assume that its object is the same as other methods of heating.

The conventional method of heating simply aims to maintain the air in a room at a predetermined temperature; in some more improved cases, moisture is added to give a relative humidity which, we are told, gives the necessary comfort according to outside weather conditions. With radiant heating, variations in the outside weather do not affect the internal conditions to such an extent, since the principle object is to control the heat loss from the human body by maintaining conditions in the room which are compatible with the physiological reactions of the human body and are conducive to a feeling of comfort in the individual. Thus, the difference between the method of heating by convection and radiant heating is partly physical and partly physiological.

Two thousand years ago the Romans had radiant heating and could boast of a more healthful heating installation than many in use today. It has been my privilege to examine some of the Roman hypocaust systems which were built two thousand years ago, and one wonders whether they knew more about hygiene and the advantages of radiant heat than we know today, or whether it was merely by accident they decided upon this most efficient and healthful method to give comfort and health.

There would probably have been a re-entry of radiant heat when James Watt, the eminent pioneer engineer, tried to heat his room with a metal tank about one hundred fifty years ago. This, however, was before Leslie discovered that a polished metal surface was a very poor emitter of radiant rays, which probably explains why James Watt turned away from this new idea in disappointment.

A. H. Barker was first impressed by the comfort effect created by a plastered wall made warm by hot flue gases from two boilers below. The two flues, built into the wall caused this room to feel much more comfortable than a similar room with cold walls, even though the air temperature in the more comfortable room was exactly the same as in the other. It was then he decided to try the effect of heating a plastered surface by casting plaster panels with hot water pipes embedded in the plaster. The initial results were good, and from that time it has been an onward march, so that today there are thousands of radiant heat systems installed in various parts of the world.

Physiology Of Body Heat

It is now generally understood that the human body requires no heat whatever from without, and that from the nutriment taken into the body, that wonderful process of Nature's mechanism called metabolism, generates all the heat required and in addition, generates a surplus amount of heat which has to be thrown away. The concept that warm ambient air is necessary to keep the body warm is fundamentally wrong. The only essential factor in dealing with heat for comfort and health is that surplus heat which we throw away. This is the fundamental basis on which the theory of "radiant heat" is built, the significance of which will be established in this discussion.

Roughly, 400 to 420 Btu surplus heat must be given off from the human body every hour. This amount of heat varies very considerably, and to indicate how it varies with posture and occupation, see Figure 1. In addition to the variation shown in Fig. 1, it also varies according to environment, age, and food.

Figure 2 shows approximately how the amount of heat generated varies according to age. In this picture the figures are given on a basis of heat per square foot since the exposed surfaces of a child are much less than that of an adult. It will be noted that at about the age of six, the heat generated reaches its maximum, but in older persons the heat generated is much lower, which explains the reason why elderly people need more protection from the cold than younger ones.

The figure 410 Btu as the amount of heat which will be given off by the average person can be divided somewhat as follows:

Radiation and convection: 300 Btu; evaporation: 62 Btu; respiration: 45 Btu per hour, with a small amount of

excreta. The radiation loss is that amount of heat given off from the body by heat rays, because the surface of the body is warmer than the surface of the surrounding walls, windows, ceiling, etc. The convection loss is the amount of heat given off from the body as the ambient air rises over the surface of the body and carries away the heat. The heat loss by evaporation is that amount of heat taken from the body as perspiration is evaporated from the skin, and the heat dissipated by respiration is the heat given to the air we breathe. While it is difficult to differentiate between radiation loss and the loss by convection, it is found that if the loss by radiation is maintained at about 190 Btu per hour and that by convection is 110

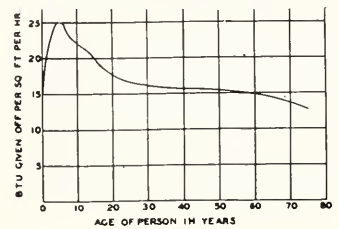


FIGURE 1

Basal metabolism according to age measured in square feet

Btu per hour, a condition of greatest comfort and health is attained.

The human body can accommodate itself within certain limits, but if the conditions of the environment and the state of the body are not perfectly correlated, the person is vaguely conscious of a strain in the thermostatic body mechanism. This question of losing heat from the body is really a complicated process, because it seems very apparent that the feeling of hot and cold is not so much a measure of the heat loss to the heat generated as it is the way in which it is lost.

Broadly speaking, the sensation of hot and cold can be avoided in two ways—either by temperature of the air being raised sufficiently high, or by warm surfaces placed in the walls, floor, and ceiling, so that the heat radiated is sufficiently intense to compensate for a lower air temperature. It must be clearly understood, however, that while some conditions stimulate the production of heat in the body, others merely dissipate the heat without in any way controlling the generation. This must never be overlooked in considering conditions of health as well as comfort.

For instance, everyone knows how a walk in the cool spring air will give us a glow of warmth from within and quickly promote an appetite, whereas when warm air surrounds the body, the heat simply crowds up on the surface of the body, which affects the vital organs and reduces the general agility of the mind and body. Since the liver is one of the largest organs in the body which generates heat, it is only natural that when the person is living in an atmosphere too warm and the heat

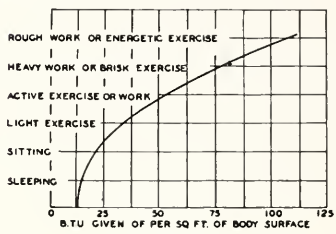


FIGURE 2

Basal metabolism in terms of man's occupation, average

from the body cannot be dissipated correctly, the liver is one of the first organs to become sluggish; hence, that feeling of lassitude invariably associated with a room or building warmed by convected heat, whether it be the home, office or in a public building.

Everyone has undoubtedly experienced the invigorating effect of radiant heat when the body has been exposed to the sun's rays on a cool sunny day in spring. Some of these rays which impinge on the body come directly from the sun and include the whole range of ether waves, while other rays coming from the sun impinge on the surrounding objects where they are increased in wave lengths and reflected to the body as low temperature radiation, thereby producing that perfectly comfortable feeling of warmth. Should a cloud pass over the sun there is instantly a sensation of cold, although in such a short interval of time, the air temperature has not varied a fraction

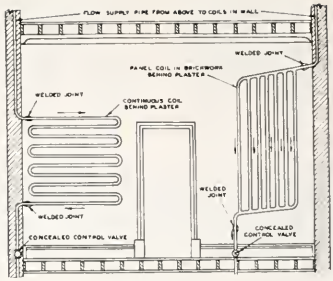


FIGURE 3

Detail showing hidden control valve for regulation of water flow

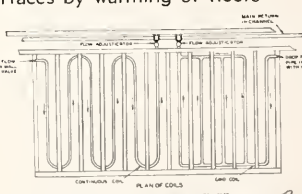
of a degree. This proves conclusively that a thermometer recording the temperature of the air is no indication of the correct comfort conditions for the human body. This same conclusion applies to any instrument recording only the air temperature, whether it is based on the dry bulb or the wet bulb reading.

Consequently, the correct basis of true comfort must be sought elsewhere. No system can be really satisfactory which does not take care of the three main factors controlling the heat loss from the human body: radiation, convection, and evaporation. The greatest of these losses is that due to radiation and consequently, it is the most important. Yet, this is the one factor which has been ignored in practically every air conditioning system installed, and is never considered when dealing with any kind of warm air or convector system of heating.

Exposed cast iron radiators of standard type give from 15% to 25% of the heat by radiation, depending on the style of radiator used, while the other 75% or 85% of the heat given off is by convection which simply burns and

FIGURE 5

Method of providing radiant heat surfaces by warming of floors



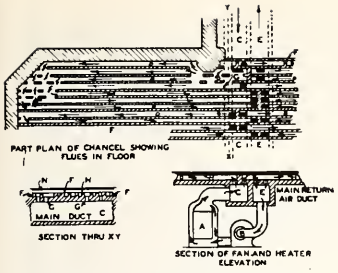


FIGURE 6

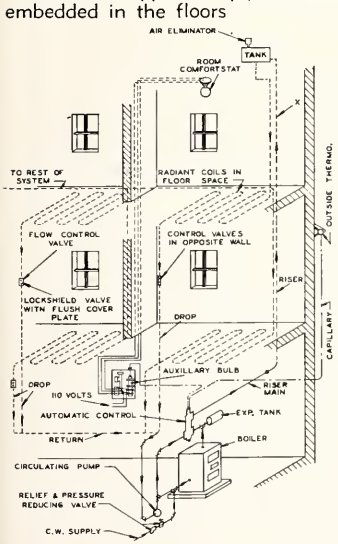
Formation of flues for Liverpool Cathedral under floor heating

drys the air as it passes over the hot surfaces. Therefore, the conclusion is that viewed from the physiological demands of the human body, the usual methods of heating and air conditioning are basically wrong in their conception of comfort.

As another demonstration of the value of radiant heat, consider how a heating system with exposed cast iron radiators will maintain a condition of comfort in a room for a longer period after the heat is shut off than will a system using convectors only; or why an air conditioning system always produces a chilly atmosphere during the interval of switching off and switching on, even though the thermostat operates within perhaps one or two degrees.

FIGURE 9

Ideal control applied to pipe coils embedded in the floors



Those radiant rays given off from the cast iron radiators are absorbed by the furniture, ceiling, and walls, and raise their temperature slightly above the air temperature. When the heat is shut off, these warmer surfaces return in a mild form of radiant rays sufficient heat to protect the body for quite some time; whereas, in the case of convectors, there are no radiant rays to warm the walls and furniture so that all surfaces in the room are at a lower temperature than the air.

Everyone is familiar with the fact that when the surface of a body is illuminated for some time by rays of sunlight, the temperature of that body is raised. In other words, it becomes

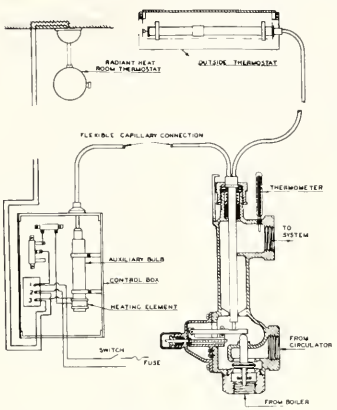


FIGURE 8

Outline of ideal weather-operated automatic temperature control

warmer because the heat energy from the sun is absorbed by the surface of the body.

It is also common knowledge that the condition of the surface plays an important part in relation to its rise of temperature. For instance, an object with a white, smooth surface does not become as hot as one with a dull, black surface. Hence, roofs and skylights of buildings are often painted white or are lime-washed in the summer. For the same reason people in very hot climates customarily wear white coverings instead of dark.

One other thing that should be observed about heat rays is that they are reflected from a surface in exactly the same manner as light rays. Thus, we

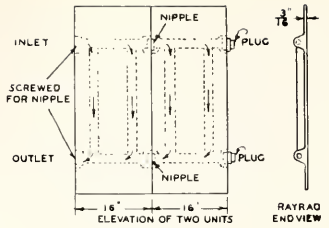


FIGURE 7

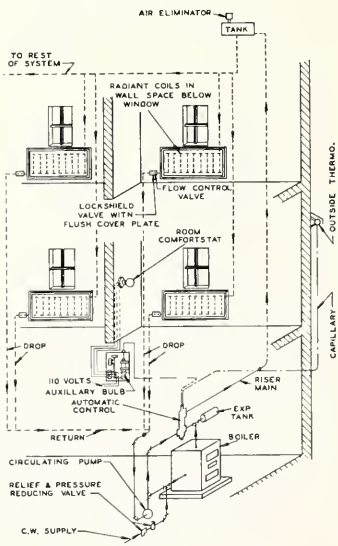
Detail of Rayrad, making possible assemblage of large units

can obtain a strong parallel stream of heat rays from a parabolic reflector when a hot element is placed at the focus. This property of reflection enables us to reflect a stream of heat rays from one direction to another, the same as a beam of light with a mirror or other reflecting surface.

Very little is really known about the exact nature of radiant heat or any radiant energy, although it is commonly assumed that all forms of radiation rays are a form of energy. Moreover, the vehicle of travel for radiant heat, etc., from place to place is not as yet definitely known, but among the explanations advanced is the one that radiant heat is a wave motion in the ether. When these wave motions strike a body, molecular vibrations are

FIGURE 10

Weather-operated control connected to Rayrad heating system



assumed to be set up and some of the energy of the waves becomes heat in the solid body. When the human body is the recipient, the heat deposited on the surface affects the nerves and the sensation of heat results. While the vehicle of transport is not definitely known, it is well established that the direction of travel of radiant energy is always in a sensibly straight line and that it always moves at a fixed speed of about 186,000 miles per second.

The question often arises as to the length of wave used in radiant heating. The wave length of ordinary light rays within the visible part of the spectrum varies between 1/37000 of an inch for the red to 1/65000 of an inch for the violet end of the spectrum. Since radiant heat is carried on at low temperature, the surface temperature varying between 90° F. and 160° F., these waves are situated very low in the infra red and have a wave length somewhere in the region of 1/10000 of an inch.

While radiant rays travel in a straight line and are unaffected by air currents, convected heat can travel only at the same rate as that of the air which carries it, and the course of the heat depends entirely on that of the air which is subject to relative weights, pressures, and velocity; whereas radiant heat travels at a definite speed regardless of air currents and temperatures. It is directional, for it can be made to impinge upon any desired object by placing the emitting surface at the correct angle to throw the rays in the direction required.

Warm air alone cannot give the benefit of radiant rays except indirectly, because warm air will gradually heat the furniture and other objects in the room. However, since all those objects must be at a lower temperature than the air in the room, all the surfaces surrounding the human body are at a lower temperature than the air, and much lower than the mean surface temperature of the human body. Mean radiant temperature of the room is much too low for comfort, and to compensate for the extra loss from the body by radiation, a high atmospheric temperature must be maintained to reduce the loss by convection. Then again, in raising the air to such a high temperature, it becomes much drier than would be the case with the lower temperature necessary with radiant heating. Thus, convection heating creates a condition of drier air, which causes a greater heat loss from the body by evaporation.

Careful consideration to these various factors discloses that by neglecting this one factor of radiation loss from the human body, there are created a whole series of faults in our heating which are unhealthy and expensive. Therefore, for correct comfort and greatest economy, it is necessary to establish what conditions are necessary to take care of the heat losses from the human body and break away from many of the old-fashioned ideas formerly held. Since the first consideration is to take care of human radiation losses, it is necessary to maintain a mean radiant temperature in the room which will control the heat loss by radiation from the human body.

The mean radiant temperature of a room does not mean the average surface temperature of walls, windows, ceilings, etc., but the average amount of radiant heat emitted from all these surfaces. This is termed the Mean Radiant Temperature or (M.R.T.) of a room. To decide what this M.R.T. shall be, it is necessary to know the mean surface temperature of the human body, including the clothes and exposed skin surface. In England this has been established at 75° F., but in America 81° F. has been assumed by the author as giving results more nearly conforming to American conditions. Much, of course, depends on the clothes worn by the person and it will be easily understood that ladies in evening dress will offer a higher surface temperature than men dressed in conventional lounge or evening suits with only hands and head uncovered.

Application Of Radiant Heating

Having considered the thermal mechanism of the human body and the required conditions to meet the heat losses, the more practical side of radiant heating may now be considered.

The first system installed in England, already mentioned, was designed by A. H. Barker, and the thermal radiations were obtained from plaster in which was embedded a coil of hot water pipes. Similar methods are still used but, generally, the heated surfaces are applied to walls and ceilings, where as in the first installation the pipes were embedded in a kind of plaster baseboard around the room, supplemented with some hot water pipes embedded in a portion of the floor extending to a distance of about eighteen inches from the side walls. In the early installations the embedded pipes were made of pewter composition, such as is often used in England for connecting city gas burners. Its general composition was four parts of tin and one of lead. At the present time wrought iron, steel, and copper pipes are used, and when embedded in plaster or concrete there is practically no difference in the Btu emitted per square feet of pipe.

The wrought iron pipe coils generally in use in plaster are made from standard one-half inch or three-quarter inch internal diameter pipes, and the pipes are formed either into a continuous coil or into a coil of grid formation, as shown in Figure 3. The pipes are usually spaced about four inches to six inches apart, and individual coils may be fabricated into any convenient size, containing any length of pipe up to two hundred feet. The joints are all welded at the factory and each coil should be tested to a pressure of three hundred pounds before being shipped to the job. When these coils are placed in the walls or ceilings they must be set back into the brickwork with a plaster covering over the pipes not less than one-half inch to three-quarter inch thick. When the coils are to be placed in a concrete ceiling, they are first placed on the wood forms before the concrete is poured, as will be shown in Fig. 10, but before any concrete is poured, or any part of the pipes covered, the ends of all the coils are welded to the vertical risers and other circuit pipes, and the whole system, or section of a system, tested hydraulically to a pres-

See RADIANT on Page 46

THE IMPACT OF THE WAR ON ECONOMIC THEORY

BY DR. PEARCE DAVIS

IT IS AT ONCE OBVIOUS that what one has to say about the topic, "The Impact of the War Upon Economic Theory", turns upon the meaning one places upon it. If we assume that the question being asked is "Did the War change Economic Theory, undermine, destroy or create Economic Theory?" it seems quite clear that the answer to such a question, or set of questions, would be in the negative. There seem to be the most substantial grounds for arguing that, at least as yet, the War has *no* significant effect upon Economic Theory; certainly it has had *no* direct effect.

The Economic Theory being discussed may be defined broadly as a collection of tools of analysis and explanations of the operation of our economy. The War we have just emerged from represented a great industrial struggle—to date the greatest industrial struggle of all time. Our part in this gigantic industrial endeavor lasted far longer than our comparable role in the First World War, required a level of exertion far superior to that demanded by the earlier struggle, and exacted a toll in energy and resources much greater than the preceding conflict.

Except in the matter of scale and intensity of effort, however, the war from which we have just emerged differed but little from the earlier one. This fact, taken in conjunction with contemporary development in theoretical analysis made it possible for our Code of Economic Theory to comprehend, anticipate, and explain most, if not all, of the economic circumstances, economic events, and economic problems that came into being in the course of the Second World War. Indeed, the relative efficiency with which our economy was organized for war, and the nation's normal economic life transformed into an industrial fighting machine, may well be consdered evidence that our pre-1941 Code of Economic Theory was reasonably mature, reasonably precise, and reasonably adequate. It is the author's opinion that the often-unnoticed and seldom-appraised influence of theoretical anlysis in a very real sense guided the transformation the nation was compelled to undergo. The stumbling, halting stages that the first days of war brought, the apparent mistakes of these same days, the delays and difficulties that loomed so large then, actually reflected frictional disturbances in the change-over of the economy rather than fundamental theoretical misguidance or theoretical inadequacies.

One could discuss with considerable interest and profit the reverse of the question at hand. One might well investigate and debate the "Influence of Economic Theory on the Conduct of the Past War."

The maturity and compartive adequacy of our Code of Economic Theory was demonstrated, it seems, in numerous ways just before and during the progress of the War. For example, it appeared in the professional and quasi-professional discussions on alternative war-time fiscal policies and, to a substantial degree, in the wartime fiscal policies actually introduced. Certainly, too, our tools of analysis were adequate to explain and guide the vast program of direct controls which were instituted, as an integral part of the war effort, in the fields of wages, prices, manpower allocation, production diversion, and import and export flows.

To repeat, it appears that a good case can be made for the contention that Economic Theory had a far greater effect on the War and the conduct of the War than the fact of war, or this particular War, has as yet had upon Economic Theory.



DR. PEARCE DAVIS

Although I have said that the past war has, as yet, had no *direct* effect upon Economic Theory, the future may well show that it had significant *indirect* influence on the Economic Theory of the postwar period. In retrospect, such influence, however, will be seen to have been one of emphasis and accent rather than any basic alteration or wholesale revision of the fundamental tenets of Economic Theory. I should like to mention some of the probable consequences that have occurred to me.

As all of us well know, one of the beneficial, though incidental, effects of the War has been the great increase in available economic data and research materials. This wartime endowment of the economists' laboratory—if fully and properly utilized—will, I believe, have a significant influence on the Economic Theory of the future in that we will thereby be provided with far more knowledge than we have had before concerning detailed operations of many portions of the economy. Our tools of theoretical analysis should become sharper and more precise. Moreover, new tools may be discovered.

A good example of such increase in research and laboratory materials is found in the comprehensive collection of wage rate data that was assembled in the course of the operations of the National War Labor Board and its subsidiary and cooperating agencies. Here is a wealth of information on intra-plant wage relationships within particular industries, inter-industry and inter-regional wage relationships. Similar accretions may, no doubt, be found in areas of economic interest outside of wages, for example, in the fields of prices, costs, and production.

A second likely indirect effect of the War will be the channeling of a greater amount of the time and thought of economic theorists, into analysis of the role of government, especially central government, in the operation of the economy. As modern war becomes more and more a total industrial struggle, it becomes increasingly inevitable in time of conflict, that the central governments of all nations will play an increasingly dominant role in the operation of their economies.

The role of government was more significant in the Second World War than the First because that war represented a more nearly total industrial struggle. Further, the increasing power of the government in economic affairs in wartime appears to lead to a progressive and accumulating acceptance of the government as a permanent factor in economic affairs. Although the Federal Government vacated most economic areas after the First World War, its economic role thereafter nevertheless remained greater than it had been prior to that war.

For similar reasons, it is to be anticipated that the Federal Government, having played a still more important role during the past World War, will remain more persuasive and more deeply involved in the present postwar economy than was the case before 1941. Postwar Economic Theory should and will address itself to the implications, potentialities, and consequences of this development.

Related to the point I have just made, in the manner of a corrollary, is the possibility that there will be sustained public, governmental, and professional interest in the place, function, and economic significance of direct control of economic activity in peace time. The unprecedented use of direct measures to influence economic adjustment, an outstanding characteristic of our recent wartime economy, seems to have established something of a precedent for federal economic intervention via such media whenever need for intervention exists or, is thought to exist. Economic Theory, in the postwar period may be called upon to re-examine and reappraise these newly emphasized methods of control. Because of our war experience with direct controls, it is to be anticipated that such manipulative devices may gain in importance relative to the more generally accepted control methods of fiscal and monetary policy.

I believe, further, that Postwar Economic Theory will have occasion to devote more of its attention to the role of the American economy in the economy of the world. This reemphasis upon international economic aspects of Theory may take place only after a certain time lag, but that it will materialize seems certain. As America is today *a* dominant if not *the* dominant element in the operation of the world economy, it follows that we shall be confronted by the necessity of making national decisions on all phases of international economic policy. Subjects such as international trade, barriers to international trade, import and export control devices will claim a larger role in theoretical analysis and discussion.

It also seems obvious that economic analysis will continue to emphasize the theory of employment and unemployment. The great postwar boom, upon the threshold of which we now stand, will in time run out. At least I now see no reason why it should not do so. When the boom is over, public and professional interest will, in all probability, again be focused on the general subject of ways and means to full employment, as that term is generally understood. Full employment is the number one economic problem of our day; its solution is the imperative requisite to the survival of American democracy as we now know it.

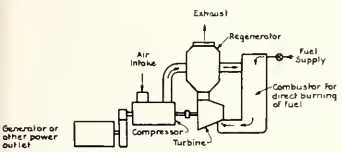
My last point refers to the impact of the War on Economic Theory *through* the impact of the War on Economic Theorists. During the past five years, as never before, economists, as a group, have participated in basic and significant governmental operations effecting innumerable phases of our economic life. As one of those economists who has so participated, I am not at all sure that I am, as yet, sufficiently detached, or "non-attached", to employ Aldous Huxley's phrase, to appraise with cool objectivity the consequences of this mass experience. In my prejudiced state, I am inclined to believe that the experience has been of profit and of benefit both to the economists and to the country. Whatever the current evaluation may be, I do believe that Economic Research and Economic Theory will shortly show the imprint thereof.

Part of an address prepared for a round-table discussion on the program of the Mid-West Economic Association meeting in Chicago, April 25-27.

Coal as Fuel FOR THE Gas Turbine

BY JOHN I. YELLOTT and A. D. SINGH

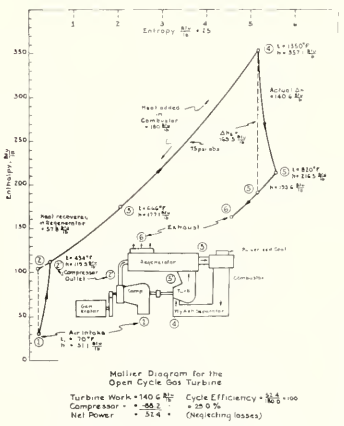
THE COMBUSTION GAS TURBINE is the newest addition to the family of prime movers by which man can convert the heating value of fuels into useful work. Simpler in principle and in operation than any of its competitors, the gas turbine was the last to be reduced to practice, because its most important component, the compressor, lagged behind the other elements in development. It was not until the introduction of the efficient multi-stage axial compressor in the middle 1930's that the combustion gas turbine became a reality. Its general principles are well understood, but, in order to illustrate particularly the factors which relate to the kind of fuel which is to be used, a brief description of the open cycle gas turbine will be given with the aid of Figure 1.



The Open Cycle Gas Turbine

FIGURE 1b

Air is drawn in from the surrounding atmosphere by the main compressor, and its pressure is raised to an appropriate value, usually about 60 to 75 psi abs. The temperature of this air, already warmed by compression, can be further raised by transferring to it some of the heat which is being discharged from the exhaust of the turbine. The regenerator can, with reasonable surface, recover from 50 to 75% of the available heat in the air leaving the turbine, and it is quite feasible to introduce the compressed air into the combustor at a temperature well above 600 F. The open-cycle combustor is characterized by the direct burning of the fuel with the necessary portion of the total air supply. The remaining air is used for cooling the combustion chamber itself, and for subsequent mixture with the products of combustion, to reduce their temperature to a level at which the turbine can operate safely.



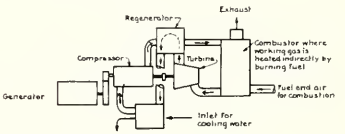
Mollier Diagram for the Open Cycle Gas Turbine

Turbine Work = 140 G Btu
Compressor = 66.4
Net Power = 74.4
Cycle Efficiency = 74.4 / 140 × 100 = 25.0 % (Neglecting losses)

FIGURE 1
OPEN CYCLE GAS TURBINE

In the case of a solid fuel combustor, some provision must be made for removing the fly ash, and Figure 1 shows a possible location for this equipment. The hot compressed air goes through the turbine, which is usually a multi-stage reaction unit, but which may be, as in the case of aircraft installations, a single impulse wheel. The exhaust gas leaves the turbine at a temperature which is still relatively high, and if adequate surface is provided in the regenerator, the heat input requirements of the system can be reduced materially. Steam for space heating or process requirements can also be generated in waste heat boilers or in a jacket surrounding the combustor.

A discussion of the factors which control the efficiency of the open cycle gas turbine is beyond the scope of this paper, but it should be pointed out that using a turbine inlet temperature of 1350 F., and recovering in the regenerator some 60% of the heat available in the exhaust, the cycle efficiency can approach 30%. When allowance is made for the inefficiency of the combustor and for the effect of pressure losses in the system, the efficiency of the cycle will still remain at about 25%. Such a value, while considerably less than the best figure obtained by contemporary Diesel engines, is still far better than the non-condensing steam cycle can accomplish. As a matter of fact, only the best high pressure, high temperature steam cycles, with regenerative feed water heating and condensing operation, can attain the same efficiency as the far simpler open cycle gas turbine.



The Closed Cycle Gas Turbine

FIGURE 2

The limitations of this cycle, however, are obvious when it is realized that about two-thirds of the power generated by the turbine is used by the compressor. The cycle requires no water, however, since the rejection of heat is done by the physical disposal of the waste gas to the atmosphere.

It is apparent that if the exhaust were to be cooled back to the temperature of the incoming air, the cycle could be closed and the same air could be used over and over again until its oxygen had been consumed in the combustion process. If an indirect air heater is used instead of a direct fired combustor, a true closed cycle exists (Figure 2) and the efficiency of such cycles under actual tests, readily exceeds 30%.

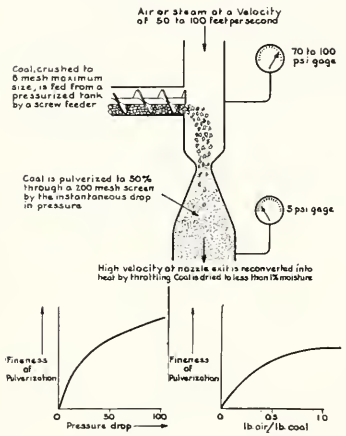


FIGURE 3
"COAL ATOMIZER" PRINCIPLE

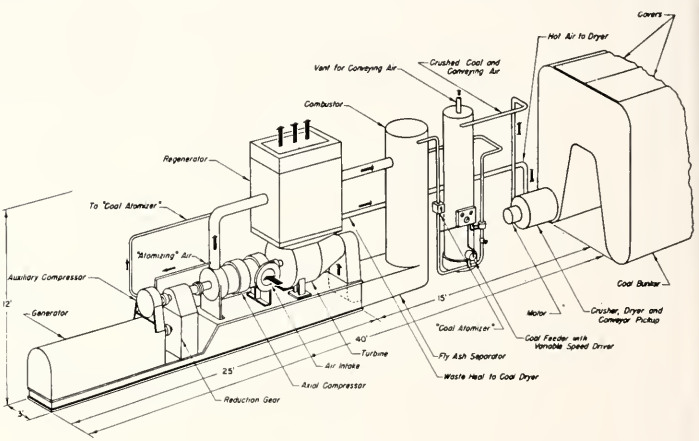


FIGURE 4
ARRANGEMENT OF COAL-BURNING GAS TURBINE

The major disadvantage of the closed cycle is the fact that it sacrifices the simplicity which is the principal advantage of the gas turbine. In addition, cooling water is necessary to reduce the temperature of the air back to a value at which the compression work will be reasonable. However, where high efficiency is desirable, the closed cycle is likely to be useful. By increasing the pressure in the working fluid so that it is operating at a level of some ten atmospheres, the power output of the turbine can be increased tremendously, and it appears that the closed cycle will have great future value for larger installations.

Since the open cycle gas turbine can be built readily for shaft outputs up to 10,000 hp, its primary competition comes from the Diesel engine. Admittedly, the Diesel has a higher thermal efficiency than the simple gas turbine can hope to attain, but the Diesel is restricted to a relatively expensive liquid fuel, whereas the open cycle gas turbine has, from its infancy, been burning solid fuels. The economics of fuels in the United States are such that coal becomes competitive with the Diesel when the thermal efficiency of the coal burner is as low as 25% of the efficiency of the Diesel.

In considering the future prospects of the gas turbine, it is important to give thought to the types of service for which it has already demonstrated its suitability. The first use of the gas turbine was probably in the Velox boiler, where supercharging was accomplished by the use of a turbine-driven axial compressor. The aircraft turbo-charger was an even earlier application, while the well-known Buchi Diesel supercharger is similar in its general principles. In none of these services, however, was it particularly necessary to generate excess power, and consequently compressors of moderate efficiency were quite acceptable.

When the Houdry oil refining process was developed, it was realized that operation at a pressure of about three atmospheres was essential. The type of turbine-compressor combination previously used for the Velox boiler was also applied to the Houdry process, but here, for the first time, the gas turbine found itself confronted with the burning of a solid fuel. The heat for operating the turbine in the Houdry process came from burning off the carbon which had been deposited upon a solid granular catalyst. Hence, from its earliest days, the power generating gas turbine has been nourished on a diet of solid fuel, and the reliability of the turbine-compressor combination in this rather exacting service has been well established.

In evaluating the most important contemporary applications of the gas turbine, it is evident that the transportation field takes first place. The spectacular rise to prominence, literally, of jet-propelled aircraft was made possible only because the continuous jet was produced by a gas turbine. This particular turbine burns liquid fuels, and it has been found that kerosene is quite as acceptable for aircraft propulsion as high octane gasoline. More recently, the turbo-jet unit has been supplemented by the introduction of the propjet, a true power turbine in which the generator is replaced by a propellor, and in which the velocity of the exhaust gases is utilized to form a

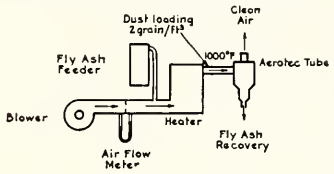
propulsion jet.

The great improvements in the field of high temperature metallurgy during the war mean that power turbines can now be safely operated with a maximum temperature of 1350 F. When it is recalled that the first Swiss gas turbine locomotive in 1939 was forced to restrict its maximum temperature to about 1040 F., it will be realized that this is actually a tremendous advance. Steam temperatures took many years to bridge the gap from 750 to 950 F., while the gas turbine has risen at least 300 degrees in maximum temperature during a period of about five years.

In determining the future usefulness of the gas turbine, the suitability of various fuels must be considered. Aircraft and Velox boiler experience have shown that liquid fuels, ranging from kerosene to heavy oil, are suitable. However, even in the United States, liquid fuels are in general considerably more expensive than solid fuels. For example, in considering the railroad picture particularly, it is seen that when purchased on a Btu basis, coal has an average advantage of about four to one in price over Diesel fuel and an advantage of almost two to one in most locations over fuel oil. This spread in price means that a gas turbine burning solid fuel with a thermal efficiency somewhere in the 20% range, will be considerably more economical in operating costs than the Diesel engine, with a 34% thermal efficiency, when the latter must burn oil which costs between five cents and six cents per gallon.

It appears that the major contest in the gas turbine field will be between coal and fuel oil, with the advantage in general turning towards coal. It is impossible to foretell the future trend in the price of heavy oil, because so many uncertain factors exist. However, as the normal automobile ownership is reestablished, the demand for gasoline will become heavier, and refinery capacity will probably be turned increasingly towards the production of the more profitable motor fuel. Likewise, the new refining processes tend to give a larger yield of gasoline, and a smaller yield of fuel oil. It seems quite probable that fuel oil will rise in cost faster than will coal, and that there will continue to be, in most parts of the United States, a very considerable spread in price between the cost of coal and the cost of even heavy fuel oil. Refined Diesel fuel will always run considerably higher in cost than coal, except in very restricted areas.

In the past, the Diesel has been competitive because it used its more expensive fuel with an efficiency of four to six times that which could be attained by competitive steam equipment. The gas turbine, however, alters this situation because when it learns to burn coal, it will do so with an ef-



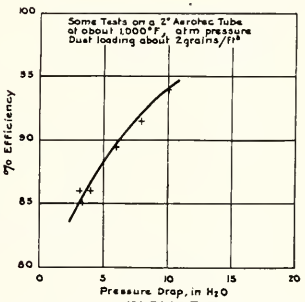


FIGURE 5
PERFORMANCE OF FLY ASH SEPARATOR

ficiency which approaches that of the Diesel. Thus, the introduction of a coal-burning gas turbine will tremendously alter the economics of small and moderate-sized power plants.

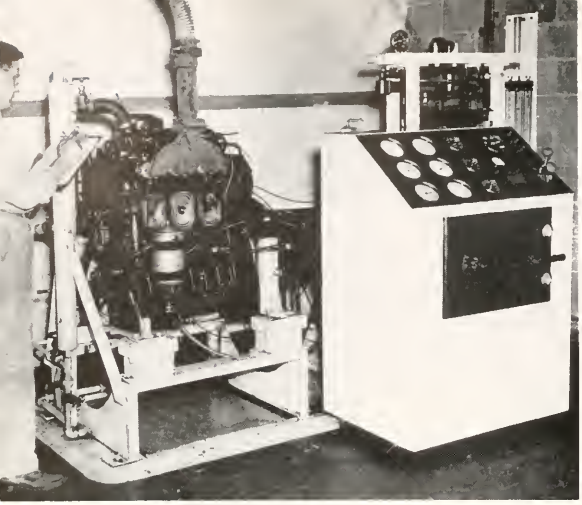
The coal-burning gas turbine should be equally adaptable to stationary and marine applications. Wherever water is lacking, the gas turbine is likely to find use. At the coal mines themselves, where large quantities of power are needed to operate mechanized equipment but where good water is customarily not present in large quantities, the coal-burning gas turbine should prove to be an economical prime mover. For marine applications, where there is plenty of water for intercoolers but where boiler feed water is at a premium, more complicated and hence more efficient cycles will be employed. If coal is used as the fuel, it is agreed that somewhat more bunker space must be provided, but the lower price of coal at most points is likely to give it economic importance even in marine service.

The major problems involved in making the gas turbine burn coal are evident from Figure 1. A system must be devised for preparing pulverized coal in such a manner that it can be burned within the limited space available on the locomotive. The solid residue in the products of combustion must be removed to such an extent that the blades of the turbine will have a reasonable life. When these problems are overcome, the gas turbine can use coal as freely as any other fuel.

Many attempts have been made to burn pulverized coal in conventional locomotives, but no such locomotive is in use at the present time. The first problem which must be solved is the pulverizing of the coal, and in many of the early attempts, the coal was prepared at track-side stations, and the locomotive tender was loaded with powdered coal. This has the advantage of simplifying the equipment on the locomotive, but it has the great disadvantage of requiring that the pulverized coal locomotive be fueled only at a few specific points.

In developing the program of the Locomotive Development Committee, it seemed to be desirable for the entire coal preparation equipment to be carried on the locomotive, and so the system shown in Figure 4 has been devised. Coal will be carried in a conventional bunker, but a special screw feeder is provided which withdraws the coal uniformly along the entire length of the bunker, and feeds it at a controlled rate to a crusher. The necessity for crushing the coal at this point arises from the fact that the pulverizer which is to be employed requires that its feed be able to pass a ten mesh screen. Likewise, it is essential that tramp iron and other foreign matter be removed from the coal at this stage. It will probably be desirable also to dry the coal at this point, in order to insure proper feed-

See GAS TURBINE on Page 42



Chevrolet, 1946 passenger car engine coupled to dynamometer and used in thermal stability research on lube oils and gasolines. Engine, mounted in a special test "cell", runs at equivalent of 60 MPH.

DEVELOPMENT AND EVALUATION OF Crankcase Oils

BY NORMAN C. PENFOLD

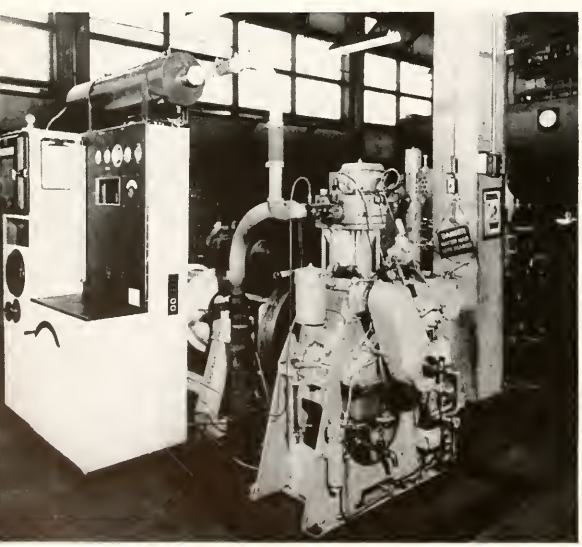
THE TERM "HEAVY-DUTY" has come to be a very significant designation as applied to crankcase oils even though many question the expression's being truly descriptive. Briefly, heavy-duty oils are those which in addition to having suitable physical and chemical properties, have also been subjected to a series of engine tests and have successfully met the requirements of those tests. Unfortunately, the engine tests used at the present time do not give test results which can be considered fundamental physical or chemical characteristics of the oil, nor do they give a numerical result such as do the conventional physical inspection tests. The test results are evaluated by competent observers and their considered judgment is an important factor in the acceptance or rejection of the oil as meeting the requirements of the tests.

Improved engine testing procedures are increasing the significance of the tests and are improving their reproducibility. The statistical analysis of the mass of engine test data now available is assisting in the improvement of the testing techniques and in the interpretation of the results. Other contributing factors are the larger number of interested persons, increased appropriations for conducting related investigations, and the increased number of engines in use as laboratory research tools.

Heavy-duty oils are usually associated with an "approval" or a "qualified" list published by the Caterpillar Tractor Company, the General Motors Corporation, or the Ordnance Department. The latter list now has about 800 oils which meet the Specification 2-104B requirements; most of these are different oils which have been qualified as a result of engine tests,—the remainder are classified as "rebrands" or "blends." It is particularly important of emphasis that no uncompounded mineral oil has been successful in meeting the 2-104B specification and that all oils listed are compounded with oxidation inhibitors, detergents and corrosion inhibitors or with addition agents which impart these qualities either singly or in combination. Recent Ordnance reports indicate that twenty-six additives manufactured by twelve companies have been qualified, in combination with various base stocks, in concentrations varying with the type and degree of refining and the susceptibility of the base oil to improvement by the additive. In addition to the inhibitors and detergents, the oils may also have pour depressants, VI improvers, foam stabilizers, rust preventives or load-carrying ability improvers.

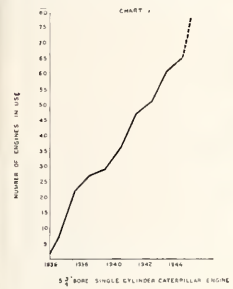
Compounding of mineral oils with additives of the modern concept began about 1850. Extensive use of these materials began about 1930 and numerous developments have been made up to the present time. The value of

"Caterpillar" single cylinder special Diesel Test engine operating under supercharged conditions for evaluation of compounded lube oils used in high-output engines. (1,200 RPM, 15 Hg boost)



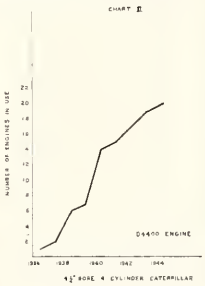
Piston taken from Diesel engine using a poor lubricating oil shows a heavy carbonaceous deposit, two top rings are stuck in their grooves, and oil ring drainage slots are plugged.





Diesel engine piston from engine using a good grade lubricating oil — all rings are free in their grooves, oil ring drainage slots are open, and there is little carbonaceous deposit.





these additives, or more properly, the value of the compounded oil, is largely determined by engine testing, there being no bench type test or inspections or other analytical means which may be relied upon to predict the performance of the lubricant in service. It is unfortunate that apparatus available to the chemist and physicist is at present lacking in this feature and it is hoped that some simple fundamental inspection or series of inspections may be found which will serve in this regard.

Present testing and inspection methods may be divided into three groups for convenience:

1. Chemical and physical laboratory tests.
2. Engine tests.
3. Field tests.

Group 1 may be further classified as follows:

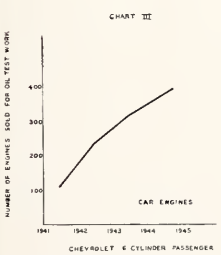
a. Absolute type tests or inspections such as those for viscosity.
b. Arbitrary tests such as Conradson carbon or Sligh oxidation.
c. Bench type tests such as the Underwood and Corrosion-stability tests.

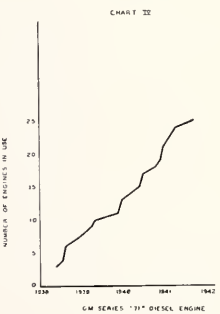
Group 2 may be subdivided as follows:

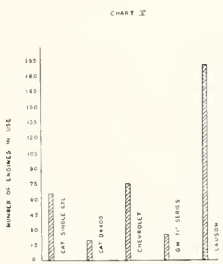
a. Small-scale engine tests.
b. Full scale engine tests.

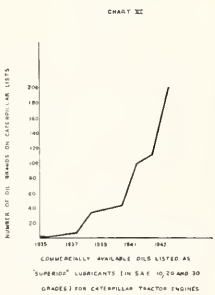
Small-scale engine tests and bench type tests are generally used as screening tests or as preliminary evaluation tools before the oil is subjected to full scale engine testing. One danger in accepting engine testing as a specification assist. is that the importance of mechanical precision and close operational control is not always appreciated. If this is the case, the adoption of engine testing may result in the introduction of variables which will reduce reproducibility of results. decrease the opportunity to derive fundamental data from the tests and make them difficult of interpretation. These difficulties may be avoided by careful selection of the engine, the use of precision standards and the development of suitable testing procedures. A specification incorporating as many of the various types of tests and inspections, engine tests included, is desirable since completeness will enable service performance to be predicted if the requirements of the use are established. In regard to the latter, will be recognized the difficulty in determining "requirements of the use" that generally makes it necessary to rely most heavily on engine tests.

The experience of the Ground Forces in calling for the use of lubricants which have met certain engine tests merits the attention. Satisfactory performance was demonstrated in all of the engine types under conditions of service from desert to sub-zero operation. It is quite possible that this excellent service record was the result of using a lubricant with a safety factor greater





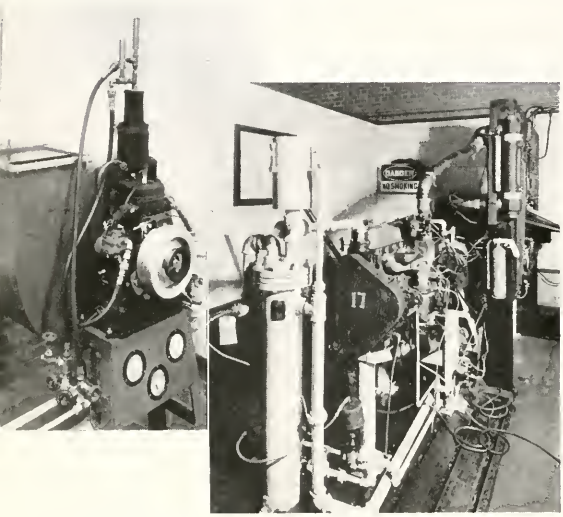




than necessary. Under the circumstances the use of such an oil was justified.

Specification 2-104B calls for the use of the following inspections and tests:

1. Gravity (ASTM D287-39)
2. Flash (ASTM D92-33)
3. Viscosity, SUS @ 100°F., 130°F., and 210° (ASTM D88-44)
4. Pour point (ASTM D97-39)
5. Carbon residue (ASTM D189-41)
6. Sulphur (ASTM D129-44)
7. Sulphated residue (ASTM ES-43)
8. Phosphorus (ASTM D809-44T)
9. Chlorine (ASTM D808-44T)
10. Metallic elements (ASTM D811-44T)
11. Viscosity Index



Used in developing and evaluating lube oil additives, this Lawson small scale, single cylinder test engine is connected to a fan dynamometer equipped with load adjustment restriction.

General Motors, 2 cycle, 3 cylinder, high-speed Diesel engine. In evaluating Ordnance Department Qualified lube oils engine operates at full load (80 HP) and full speed (2,000 RPM) for 500 hours.

12. Pour point, 20% dilution
13. Detergency—CRC Designation L-1 test (AXS 1551)
14. Accelerated run-in—CRC Designation L-2 test (AXS 1552)
15. Detergency and Bearing Corrosion—CRC Designation L-3 test (AXS 1553)
16. Oxidation Resistance—CRC Designation L-4 test (AXS 1554)
17. General Motors 500-Hr. test—CRC Designation L-5 test (AXS 1555)
18. Stable Pour—CRC Designation L-11 test (AXS 1561)
19. Foaming—CRC Designation L-12 test (AXS 1562)
20. Armour Homogeneity and Miscibility
21. Miscibility range

For those not familiar with the engine tests, CRC Designation L-1 through L-5, the following descriptions may prove helpful:

1. *"Caterpillar" Class I Test.* Conducted in a single-cylinder "Caterpillar" Diesel engine. The test is essentially an endurance type investigation, and operating conditions are not increased in severity in order to accelerate deterioration of the oil. An inspection of the engine parts after a 480-hour test enables the prediction of probable oil performance in terms of 6,000 to 8,000 hours of engine operation. Operating conditions are as follows:

   Speed.....1,000 R.P.M.
   Oil temperature to bearings.....150°
   Jacket coolant outlet temperature..180°
   Fuel.....straight run Diesel fuel
   Fuel input rate.....2950 B.T.U./min.
   Power output (5¾ inch x 8 inch engine).....approximately 21 B.H.P.
   Oil change periods.....120 hours

2. *"Caterpillar" Class II Test.* Conducted in the same engine as 1, with modified cylinder head, combustion chamber, connecting rod, piston and other changes. This test measures the ability of an oil to prevent piston ring and cylinder scratching* and scoring under conditions of accelerated run-in. Operating conditions are as follows:

   Speed .....900 R.P.M.
   Duration .....
   3 hours plus 20 minutes run-in
   Fuel input.....2460 B.T.U./Min.
   Jacket temperature and oil temperature .....Normal

3. *"Caterpillar" Class III Test.* Conducted in a D-4400 unit (4-cylinder Diesel engine) was originally used to determine performance of oils under desert operating conditions where jacket coolant temperature, air inlet temperature, and sump oil temperature would be high. Characteristics evaluated are similar to those in the Class I test with the exception of the higher temperature effects and the additional information obtained on copper-lead bearing attack by the oil. Operating conditions are as follows:

   Speed .....1400 R.P.M.
   Load .....37 B.H.P.
   Inlet air temperature.....140°F.
   Jacket water outlet temperature .....200°F.
   Oil to bearings temperature.....212°F.

4. *Chevrolet 36-hour Test.* Conducted in a Chevrolet 1942 6-cylinder passenger car engine to determine oxidation stability and bearing corrosion characteristics. Gasoline with 2½ to 3 ml T.E.L. per gallon is used and must be carefully selected to avoid excessive fuel varnish formation at one extreme. Operating conditions are as follows:

* Conditions conducive to scratching are accentuated by direction of the burning fuel from the burner tube towards the anti-thrust side of the cylinder. Better control of the "scratching" tendency of the parts is obtained by this localizing.

See CRANKCASE on Page 62



The Consumer & Product Design

BY EMMET J. LOWRY

THE CONSUMER IS THE JUDGE. It is consumer acceptance of a particular product which creates demand. The pressure of this demand indicates consumer satisfaction with a specific function in a certain form.

Will it sell? That is the question uppermost in the minds of the manufacturer, the distributor, and the retailer when appraising the physical form of a new product.

The responsibility for consumer acceptance rests with the product designer. Those factors which contribute to greater ownership satisfaction are the chief means of changing a prospect to a customer.

From the standpoint of the manufacturer design quality is important because he has a product to sell and any quality that makes people want to buy is good business. The consumer, on the other hand, has three qualifying stimuli to his primary urge to possess through buying—reduced cost, improved function, or better appearance.

Reduced cost to the consumer is one of the aims of good product design. This may be achieved by a greater simplicity of form and/or the use of better material or the selection of a more suitable combination of materials. Thus insuring the consumer more for his dollar in durability and utility values.

Improved function is an important contribution not only to consumer satisfaction but also to the prestige of the manufacturer's name or symbol. Various solutions are possible: it may be sufficient to make it lighter, easier to clean, operate more efficiently, more economically, or merely take up less space.

Better appearance, popularly treated as an intangible, should, on the contrary, be the direct result of the successful execution of the aforesaid aims of the product designer. It may be a more pleasing form, a more appropriate texture or finish, or a better color harmony. Thereby fitting the object more perfectly into its environment.

Objects of mass production—refrigerators, washing machines, ironers, toasters, and such—are particularly adaptable to this new art. These products, lacking the interpretive touch of the craftsman common to traditional lines such as wooden furniture, hollow silverware and the like, can be made into well-designed forms which solve both the functional and psychological needs of the consumer. As such these forms should be an expression of the plastic or form-giving sensibility of the 20th Century designer.

But why is a product designer necessary in a market where consumer demand surpasses the manufacturer's ability to supply?

Frankly he isn't. This is more or less the case, for example, of a utility company which enjoys a monopoly in a certain community and has no problem in selling its product. An appliance manufacturer, on the other hand, wishing to satisfy completely the market demand for a new electric iron has, in normal times, the twin problems of competitive products and a saturated market.

The designer then has not only the problem of solving consumer's needs in their basic form, but also of doing it better than his competitors. However his function demands an outlook

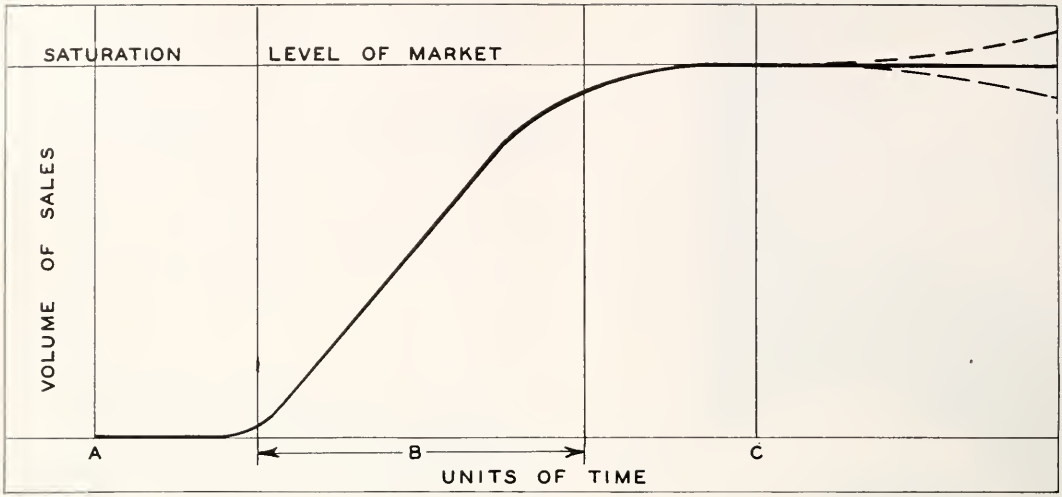


FIGURE 1

toward relative rather than absolute perfection.

The philosophy that a fundamental design problem has only one ideal solution is not justified in practice. Large radio manufacturers featuring a hundred or more different models in current lines demonstrate a case in point. Each model is engineered to meet specific "end-use" requirements and demands distinctly individual design for identification and promotional purposes. Models are not only qualified by their relation to other items in the line, but by the forms of competitive products at the same market level.

The growth curve in the life of a product is the clearest way to illustrate the development of the need for the product designer and the point at which this need becomes critical. Figure 1 is the complete curve of an entirely new product. Today finds most products in the B portion of the graph, as stored up demand definitely places the emphasis on quantity rather than quality. Real design progress must, in the final analysis, depend on a return to normal, competitive conditions.

An entirely new product can be an invention for which there is a definite use. A, Figure 1, indicates the start of such a marketing project. At this point the manufacturer is primarily interested in a return on his investment. Along with the tools of production and the materials for processing, this investment generally involves an engineering redesign for mass manufacture and a styling for consumer acceptance. This styling is usually based on a likeness to other objects common to the product's end-use environment, be that the kitchen, the bathroom or whatever it might be. In many instances the restyling may have its basis in a visual likeness to the object which it replaces in function. A striking example of this practice is a modern, all-electric space heater shaped exactly as was the steam radiator which it duplicates in function. Then too there are many products on the market processed in metal yet with definite wood grain finishes. Despite the vagaries of design attendant to this procedure, products are marketed and if functionally desirable meet immediate consumer response.

Throughout B on the graph the determining factors are sales promotion, advertising, and channels of distribution. Expansion is taking place, not alone in the marketing sense but in the physical elements of production as well. The duration of this phase will naturally vary with the nature of the product and the difficulty with which it can be copied by competitors or simulated in function without infringement.

At C the saturation level of the market has been reached. This may be a natural saturation or may be due to competitive operation. Manufacturing interests find this position unsatisfactory for one or both of two reasons: competition is stronger or more efficient production is in operation. Internally, unit cost is reduced and the commodity output per unit of time is accelerated while consumer demand remains relatively stable. This is the time when the problem of expanding the market becomes acute for the manufacturer and the product designer has his greatest opportunity.

Actually it is in his province to determine whether product demand falls off, stays on the level, or shows an increase.

The designer, at this point, is confronted with a number of variables, the first of which is the consumer. As individuals the consumers will have different standards, social aims and moral values. In consequence individualized consumer preferences are apt to run a gamut of conceivable forms, colors, and textures. A translation and an averaging of the myriad wishes of the group at any purchasing power

See CONSUMER on Page 34

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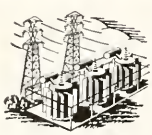
* * *

There is hardly a manufactured thing employed or enjoyed in modern good living—to which Allis-Chalmers engineering "know-how" does not contril

The steel and concrete that the city's skeleton . . . the ele power that brings it to life . . . the w supply and sewerage facilities . . turning wheels of its industries . . very bread on its breakfast tables these and more, Allis-Chalmers chinery helps bring to *your* good li

But it is not bigness alone





For the producer, distributor, or user of commercial electric power, Allis-Chalmers provides new and improved power generating units, transformers, unit substations, switchgear, control, circuit-breakers, switchboards, rectifiers, converters, regulators, motors, and scores of other electrical products. In electrical equipment, Allis-Chalmers is a good name to know.

ALLIS-CH

◀ One of the Big 3 in Electr

Biggest of all in F



YOU SEE?

ade Allis-Chalmers one of the greatest industrial names. It is ndness of Allis-Chalmers engi—the integrity of workmanship aakes every product stamped great.

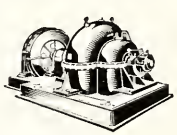
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CONSUMER

[*Continued from Page 30*]

level becomes the primary objective of the product designer.

Considered in this light a product can never be merely an isolated physical thing, it must always, in the mind of the designer, be a skillfully composited expression of many vital relationships. It must not only perform efficiently but also contribute to an emotional satisfaction on the part of the consumer. Granting that the operating efficiency of two functional forms is equal, the aesthetic sensibility can still make a choice. Those psychological factors which impel the selection of one form over the other are the concern and responsibility of the designer.

The aesthetic impulse exists in all consumers, be his estate high or low, but the average buyer will select only on the basis of two criteria—agreement with experience and intelligibility. This accounts for the ready acceptance by the consumer of those things which are modern, streamlined, or styled in the buyer's experience.

The consumer is told about the product before seeing it. He imagines the actuality of the object before experiencing it, as a result of the information supplied him through all the advertising media at the command of the manufacturer—the radio, the magazines, the newspapers, etc. Unless his education has made him acutely aware, these preconceptions govern his whole view of the product.

These preconceived ideas form one of the variables for the product designer, but it is the one which is most easily controlled. Through advertising and with the cooperation of various other powerful instruments of information at the control of the manufacturer, the designer is in a position not only to create new forms of beauty and utility, but also to create the proper conditions necessary to an unbiased reception and appreciation of his efforts in the eyes of the consumer.

Other variables of a more practical and technical nature also inhibit the designer's freedom. These have to do with plant facilities, engineering requirements, company policies, packaging, distribution, and competition as are shown in Figure 2.

The range and variety of the many influences and considerations that must be resolved in the physical form of the product can be easily seen in this graph.

Any summation of the efforts of sundry talented though ill-assorted technicians cannot add up to beauty of any kind, particularly in the design of a product, without a focal point of coordination. The coordinating action is the proper function of the product designer.

Of the innumerable forms it is possible for any one manufactured article to assume, the one which contributes the most in the way of ownership satisfaction as a result of this coordinating action is the form in which the desires and preferences of both the consumer and manufacturer can be realized.

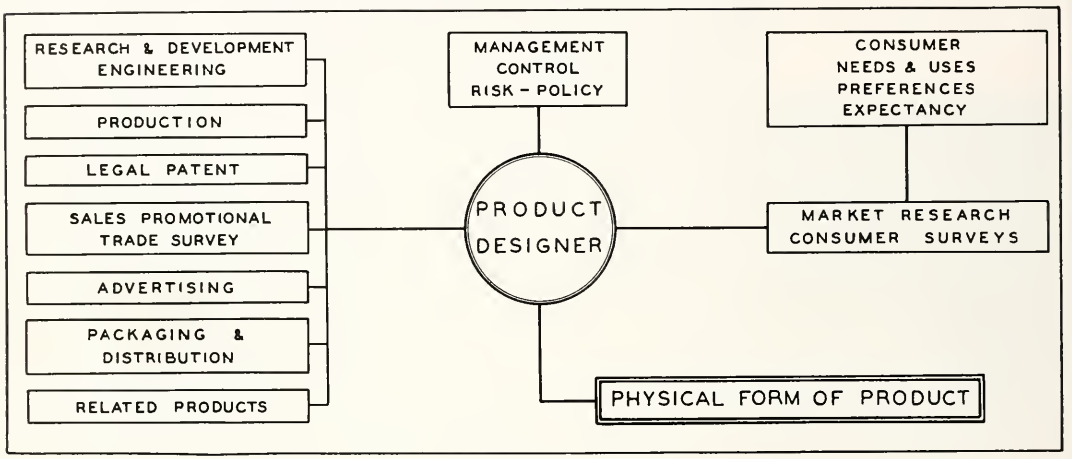


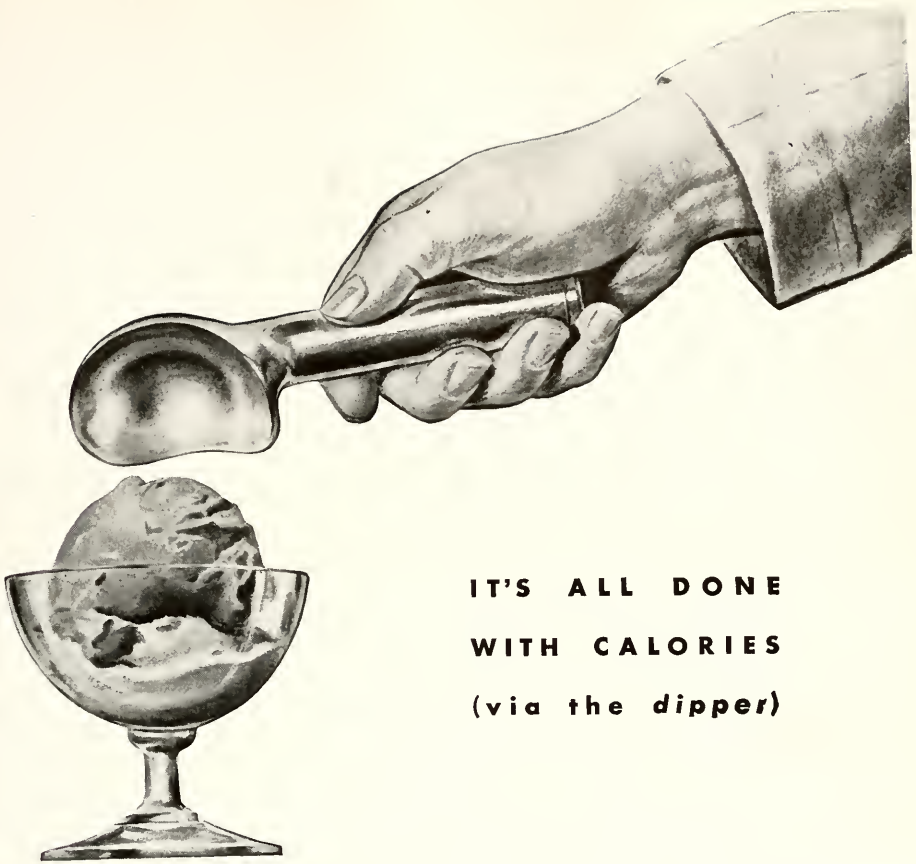
FIGURE 2

CONTRIBUTORS AND CREDITS

John I. Yellott is Director of Research for the Locomotive Development Committee of Bituminous Coal Research, Inc., Baltimore, Maryland. He was formerly Director of the Institute of Gas Technology of Illinois Institute of Technology, and, previous to that was Director of the Mechanical Engineering Department at Illinois Tech.

Mr. Yellott graduated from John Hopkins University in 1931 and earned his Master of Mechanical Engineering degree there in 1933. Prior to joining Illinois Tech, Mr. Yellott was Chairman of the Department of Mechanical Engineering at Stevens Institute of Technology.

As Director of the Illinois Tech Engineering Science and Management War Training program, Mr. Yellott became outstanding in war education circles. The safety program he devised at Illinos Tech was adopted by the Department of Labor as the national program.



IT'S ALL DONE WITH CALORIES (via the *dipper*)

There's been an endless parade of mechanisms to eject ice cream from dippers.

But somebody noodled... "Why not make a dipper with no moving parts?" Make it so that calories of heat from the user's hand shoot right down the handle to the cup. Then the ice cream will drop out easily.

That called for a material that transfers heat fast. So the dipper was made of Alcoa Aluminum, and the hollow handle filled with liquid. And, by golly, it worked . . . perfectly. The dipper sells.

No "Einstein" at work here . . . just plain American ingenuity of the kind graduated every year from our colleges and universities. Imagination plus engineering . . . or "Imagineering" as we like to call it at Alcoa . . . did the trick.

This is just one example of invention and adaptation of things *aluminum* . . . of men with ideas working them out in this versatile metal. Men who do this often draw upon the greatest fund of aluminum knowledge in the world . . . Alcoa's. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN ALUMINUM

RESEARCH

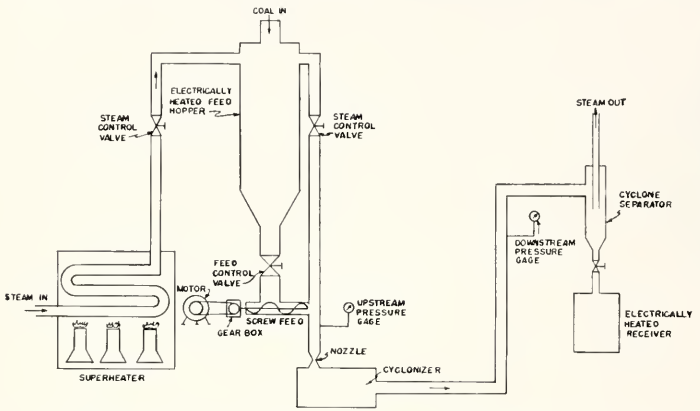
[*Continued from Page 16*]

discernable difference in true and apparent specific gravity when the "char" contained 29.6% volatile as compared with 22.9% volatile. The coke shatter tests gave substantially lower yields of breeze and higher yields of larger sized coke with an increase in volatile in the "char" from 17.25 to 29.6%. The tests are incomplete but indicate that "fluid" partial devolatilization is a potential method for extending the quantity of coals for blending purposes. The process has one distinct advantage when using high sulphur coals in that from 40 to 60% of the sulfur in the coal is distilled with the gas and tar leaving a "char" containing from 60 to 40% of the original sulphur content. Some of the experimental results were reported to the American Gas Association Production and Chemical Conference on June 5, 1945.[4]

The fluid technique has been proposed for controlled partial oxidation of coal with studies of accompanying changes in plasticity, agglutinating value and thermal expansion. The proper approach to the study of the effect of partial oxidation upon coking qualities of coals is under consideration at the Institute at the present time.

The research activities of the Institute in gasification have necessitated a complete exploration of the steam-oxygen-carbon reactions as influenced by temperature, pressure, and concentration. This research was initiated under the sponsorship of the Gas Production Research Committee of the American Gas Association in 1945 and has been extended into 1947. The work to date has been concentrated on a compilation of the available data on heats of reactions, changes in free energy, and in the kinetics of the simultaneous reactions involved in the design of a reactor to operate at controlled temperatures and atmospheric pressure. The construction of the pressure reactor has been materially delayed by inability to obtain materials but the research is being prosecuted as rapidly as conditions permit.

The study of the steam-oxygen-carbon reactions requires as a corollary a determination of the relative reactivties of the carbon used. This determination is in itself a full-sized long-term research project of great importance to by-product coke oven and blast furnace operators. Several attempts to determine reactivity have been made but always at temperatures well below the level encountered in gas making or in blast furnace operation.[5] These attempts have not been correlated with simply determined physical properties because suitable means or tools have not been available. The Institute of Gas Technology is very anxious to attempt the development of reactivity tests which are comparable with conditions encountered in practice and to employ one or more of the newer methods of measurements to correlate, if possible, a simple physical or chemical measurement with observed reactivities. The Institute has available, either in its own or in the laboratories of its affiliates, Illinois Institute of Technology and the Research Foundation, infra-red and ultra-violet spectrometers and X-ray diffraction apparatus for measuring chemical properties and an electron microscope for the study of porosity and coke microstructures.



Flow diagram of the flash pulverizer for research comminution of crushed coal or coke.

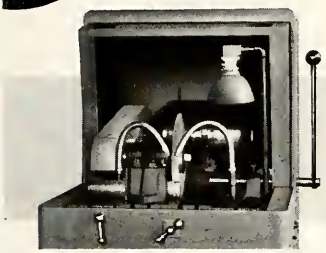
Additional equipment will be added as it becomes available to extend this study of the chemical and physical properties of coal and coke which influence carbonization and gasification characteristics and to interpret and correlate these properties with the presently accepted methods of test for strength and hardness, plasticity and agglutinating value. The Institute's experimental coke oven has already been employed in testing blends of coal and coal and inerts for coke making. The experience gained in these tests will be available to assist in making the interpretations outlined above.

When definite types of carbon can be identified it has also been proposed that the origin of this carbon be determined by tagging particles of the raw materials in the mix before blending with radio-active substance and then following the progress of these tagged particles through both the carbonization process in the Institute's experimental oven and the gasification process in one of the Institute's reactors. It is believed that exploratory studies employing this technique are highly desirable as the importance of these processes in industry cannot be overestimated. Every effort should be made to determine the influence of raw materials and carbonization and gasification conditions upon reaction rates and capacities and yields.

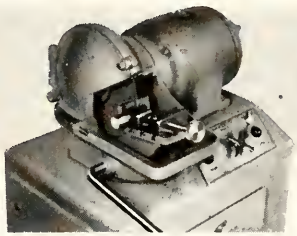
(Continued on Page 38)

Buehler SPECIMEN PREPARATION EQUIPMENT AND SUPPLIES FOR THE METALLURGICAL LABORATORY

The items illustrated are selected from the complete Buehler line of equipment, tools and accessories for molding and finishing specimen mounts.



Abrasive Cut-off Machine, Model No. 1000, is a solidly built, heavy duty piece of equipment free from sideplay or vibration with capacity for cutting specimen sections up to 3-1/2". Cutting is done on the front of the wheel and is controlled by a convenient outside lever. The driving motor is a totally enclosed ball bearing, 3 hp. with a separate motor driving the self-contained cooling system. Overall dimensions of cabinet 31" x 47" x 64". Shipping weight, 1400 lbs.



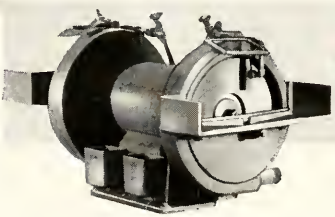
Model No. 1010, a 1 hp. Cut-off Machine with cutting wheel mounted directly on motor shaft. Motor is ball bearing completely enclosed with sufficient power for fast cutting of samples up to 1" diameter. Overall dimensions 24" x 28" x 50". Shipping weight, 575 lbs.



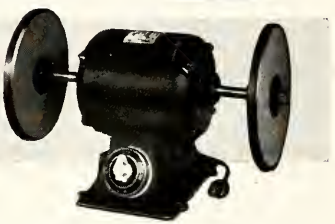
Specimen Mount Press No. 1315 has complete accessibility, no enclosed parts. Smooth performance permits speed and accuracy in operation. Solid heater can be raised and the cooling blocks swing into position without releasing pressure on the mold. This rapid cooling permits production of transoptic mounts in a few minutes. Shipping weight, 100 lbs.



Heavy Duty Wet Power Grinder No. 1215, for coarse and medium coarse grinding. The entire surface of the 12" wheel is exposed for grinding; thus providing a wide range of grinding speeds. A self-contained recirculating cooling system supplies a soluble oil coolant independently to each wheel. A feature of this machine is its freedom from vibration. Shipping weight, 435 lbs.



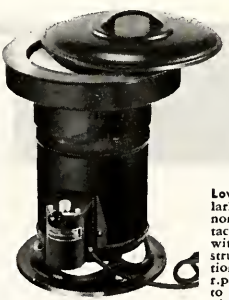
Wet Power Grinder No. 1210, powered with a 3/4 hp. totally enclosed ball bearing motor has two 12" water cooled wheels fitted with closed-in guards and non-shatterable shields. Suitable for coarse and medium grinding. Shipping weight, 310 lbs.



Emery Paper Disc Grinder No. 1400, motor shaft is extended to provide four grinding surfaces for four grades of emery paper. Emery paper discs 8" diameter are held in place by a convenient two-piece clamp. Motor is 1/3 hp. with two speeds, 575 and 1150 r.p.m. Shipping weight, 75 lbs.



Hand Grinder No. 1410 is a most conveniently arranged two stage grinder. The grinding surfaces are 4-1/2" x 12-1/4" each with heavy 7/16" thick plate glass back. A reserve roll of 150 feet of emery paper is contained in drums for quick renewal of grinding surface. Base has gutter drains for surplus liquid in wet grinding operations. Shipping weight, 95 lbs.



Standard Polisher No. 1500. A complete unit with direct mounted 1/4 hp. radial thrust ball bearing motor. The 8" polishing disc is attached to a tapered arbor on the motor shaft by means of a stout sleeve. This sturdy construction and unusually smooth vibrationless operation helps to prevent pitting and amorphous film in polishing. The removable splash ring forms a convenient hand rest that aids the operator in precision work. A handy control lever on the mounted switch gives selective speeds of 575 and 1150 r.p.m. Shipping weight, 100 lbs.



Low Speed Polisher No. 1505-2, is particularly adapted to final stage polishing and for non-ferrous metal samples. The 8" disc is attached to a countershaft by a tapered sleeve with a long span between bearings, a construction feature that assures smooth operation. The selective speeds of 150 and 250 r.p.m. make this polisher perfectly adapted to the wax lap or lead lap polishing technique. Shipping weight, 105 lbs.

Either the standard or low speed polishers can be furnished in a single unit table model polisher No. 1516. A three unit table model No. 1540 is also available for maximum convenience in three stage polishing.

In the complete line of Buehler accessories and supplies for the metallurgical laboratory are found: Abrasive paper sheets, discs, and rolls in every grade • polishing solutions • polishing cloths • cut-off wheels and molding powders. Buehler service includes everything needed for preparing precision specimens from metallurgical samples, available from one reliable source.

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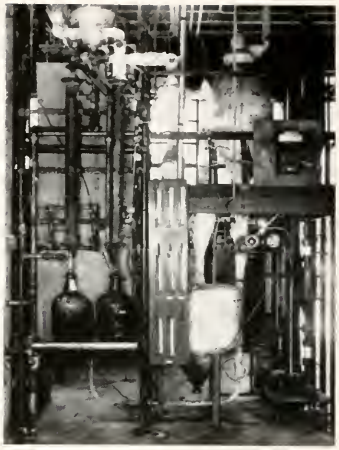
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The Institute has engaged in one other research activity that has received considerable publicity. This activity has been the development of continuous controlled explosive or "flash" pulverization of permeable solids using air and superheated steam.[6,7] The process has one significant application, the pulverization of coal with air for the combustion gas turbine, in which the ratio of air to coal is governed by combustion requirements. In similar applications where the ratio of fluids to solids is governed by the end process and is 2 to 10 to one as in partial or complete gasification in the "fluid" state or in suspension, and when the cost of pulverization is absorbed by the fluidizing or transfer medium, the "flash" pulverizer appears to offer a satisfactory solution to an old problem. The simplicity of the pulverizer appeals to the most skeptical.

The Institute is continuing the study of the use of the flash pulverizer in the comminution of coke breeze for blending in by-product coke oven mixes. Tests made by the Rochester Gas and Electric Corporation and the Philadelphia Coke Company and reported to the American Gas Association[8] have indicated that with adequate pulverization, coke breeze can be blended satisfactorily and without detriment to the structural properties of the finished coke. The maintenance of mechanical pulverizers when comminuting coke breeze was prohibitive. The costs of pulverization using the flash pulverizer and air or superheated steam have yet to be established.

The oldest research activity of the Institute of Gas Technology has been the development of a procedure for the determination of organic sulphur in gases. The progress of this work has been reported on two occasions, the most recent being in a paper[9,10] presented to the Production and Chemical Conference of the American Gas Association, June 4, 1946. This research has been cooperatively sponsored by the Organic Sulphur Subcommittee of the American Gas Association and the Rochester Gas and Electric Corporation.

The development of organic sulphur determination techniques has now reached the point where city gas can be tested in the field by cooperating agencies to determine the types of organic sulphur which would have to be removed in the various natural, manufactured, and mixed gas distributing areas to provide for sulphur free gas. The data obtained from these tests will then be used in the developing and testing of chemical absorption methods of organic sulphur removal and in the study of "Sulphur Resistant Catalysts" for the selection of those catalysts which will be effective in the shifting of the individual organic sulphur compounds characteristic to those gases to inorganic forms which may be removed without destroying the utility of the gas. This second phase will be carried out as a fourth part of the study of "Sulphur Resistant Catalysts" sponsored by the Gas Production Research Committee previously mentioned.



Experimental char maker, the flow chart of which is seen on Page 16.



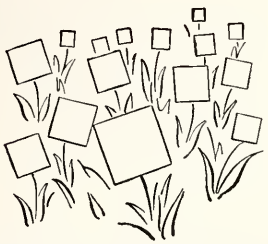
Pulling a test charge from the Gas Institute's experimental coke oven located at Technology Center.

The above outline indicates some of the research activities of the Institute of Gas Technology that have points of interest to the by-product coke industry. These research activities are sufficient justification for the existence of the Institute. However, the Institute of Gas Technology has an objective of equal or possibly greater importance which has been held in abeyance during the war years, the training of men at the graduate level for the gas industry. In discussing this major objective of the Institute, the writer would like to quote a statement made by Ernst Mahler, Executive Vice President, Kimberly-Clark Corporation, Neenah, Wisconsin, and Trustee of Lawrence College, before the 1944 Executive Conference of the Institute of Paper Chemistry, as follows:

(Continued on Page 40)

NUMBER 3 OF A SERIES

Newsworthy Notes for Engineers



Victory Garden of Crystals

Most synthetic crystals contain water. Under sustained operation, heat drives off the water, destroys the crystal. To lick this trouble—which put vital Navy electronic apparatus out of action, new equipment using a water-free synthetic crystal was developed by Bell Telephone Laboratories.

It was the job of engineers at Western Electric to set up equipment for *growing* synthetic crystals on a mass production basis.

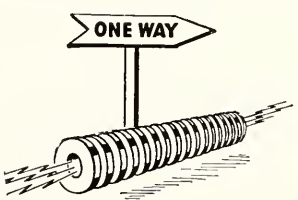
For "seeds" they use tiny pieces of crystal, "planted" in metal pans. Temperature is raised to 110° F, ammonia salt solution is added, the pans are rocked gently by mechanical means. Lowering the temperature starts crystallization. After several days, the salt solution is drained. Then the process is repeated for from 45 to 60 days.

Result: synthetic crystal bars six inches to a foot in length from which the electronic crystals—better than nature's own—are cut.

Electrical One-Way Streets

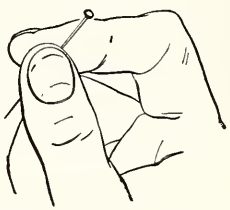
To one group of Western Electric engineers, every day is baking day. The objects of their culinary skill are copper washers and discs—from 1-16th to 1½ inches in diameter—done to a turn in a red hot oven, and with a crust of copper oxide on one side.

Piled in matched sets, these copper oxide discs are called *varistors* (variable resistors). They are high resistance in one direction, low resistance in the other, and so, in effect, allow electrical current only a one-way passage.



As radio moved into very high frequencies, specifications for precision, stability and smaller size of these rectifiers went far beyond anything previously attempted outside the laboratory.

Western Electric's manufacturing engineers set up shop for quantity production of these interesting little devices. The techniques they have developed have great significance for post-war communications.



Smaller than a Pinhead

Thermistor—thermal resistor—is the name of a class of solid variable resistors used as circuit control elements. These tiny units must be sturdy and dependable, yet extremely sensitive in response to temperature variations.

Most thermistors begin life as a metallic oxide paste. This is processed; "fired" under carefully controlled atmosphere and temperature conditions; then formed into beads on fine wires, pressed into discs or extruded as rods.

One interesting manufacturing problem arises from their size, which may be smaller than a pinhead. To manufacture these tiny devices, some of the operations must be performed under microscopes.

Developing and setting up techniques for quantity production of these precise units is another accomplishment of Western Electric engineers.

Manufacturing telephone and radio apparatus for the Bell System is Western Electric's primary job. It calls for engineers of many kinds—radio, electrical, mechanical, chemical, metallurgical. Many of the things they do —whether seemingly little or big—contribute greatly to the art of manufacture of communications equipment

Western Electric

SOURCE OF SUPPLY FOR THE BELL SYSTEM



Because of felt's extreme versatility, it is used in an enormous number and variety of products as channels, pads, gaskets, wicking, weatherstripping, thermacoustic insulation, etc.

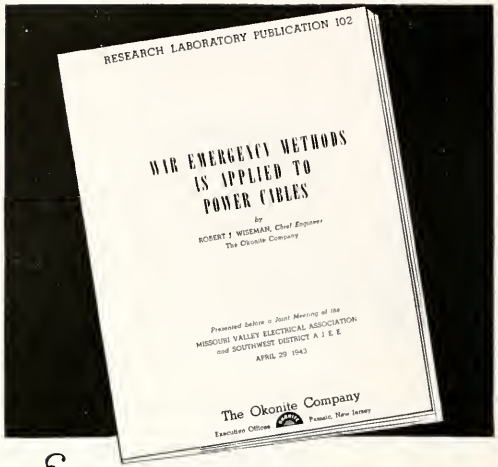
Processed by Western Felt Works in grades ranging from wool softness to rock hardness, and in practically any shape and size, felt is useful wherever the job requires resistance to heat, age, water, oils; resiliency, flexibility, compressibility, or many other properties.

Western Felt Works engineers will assist you in determining possible uses for felt in your products. *Write us today.*

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*By R. J. Wiseman, chief engineer of The Okonite Co., presented before a joint meeting of the Missouri Valley Electrical Association and Southwest District A.I.E.E.

OKONITE
INSULATED WIRES AND CABLES
3722

[*Continued from Page 38*]

". . . What seems to me to be the outstanding feature of the Institute . . . is the recognition of the fact that man is the common denominator of all problems. Politically and economically, we speak of 'systems.' Industrially, we refer to competition for markets. Actually, everything resolves itself into the character and education of men. In our businesses, we are inclined to think of the future in terms of materials and machinery. In the final analysis, however, an industry's success is dependent on the wisdom and stature of the men who comprise it. While industries compete in services and products, their ultimate competition is for manpower."

Paraphrasing Mr. Mahler's remarks, the Gas Industry and the By-Product Coke Industry, in fact, each, must see that it gets at least its share of outstanding young men wherever they live or whatever their previous interests may have been. If we succeed in this, we shall succeed in all else.

The Institute's training activity has been revived with the reestablishment of its educational program starting with the academic year 1946-47. With the purpose of training those outstanding young men who are attracted to the Gas industry, the program offers four-year Fellowships leading to the degree of Doctor of Philosophy and two-year Fellowships leading to the degree of Master of Gas Technology.

All Fellows are to be enrolled in the Graduate School of Illinois Institute of Technology and will be required to earn the degree of Master of Gas Technology in the first two years by completing courses in gas production, distribution and utilization, labor relations and public utility regulation, as well as a thesis in Gas Technology.

Plans have been completed for the 1946-47 year with the appointment of nine Fellows under the new program. Eight of the appointees are new students and will work for the master's degree, while the ninth, who has received his master's degree from Illinois Institute of Technology, will work for the doctorate. With this start it is felt that the Institute of Gas Technology will be greatly assisted in attaining its research objectives.

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* With additions to the original paper prepared for presentation at the First Annual Meeting of the American By-Product Coke Institute held at Absecon, New Jersey on June 17, 1946.



Prophet, *with* honor . . .

"Had a Jules Verne sought to imagine some universal servant of mankind, he would well have depicted some *magic agent* which would apply Nature's forces to do man's work . . . which could take the energy out of hidden coal and falling water, carry it by easy channels and cause it to give the light of a million candles, the power of a thousand men — or to produce heat without combustion, and unlock chemical bonds and release new materials . . ."

These are words of George Westinghouse, prophetic words because he uttered them many years ago on the subject of *electricity* — and then, as inventor and forward-looking industrial leader, did much to make them come true.

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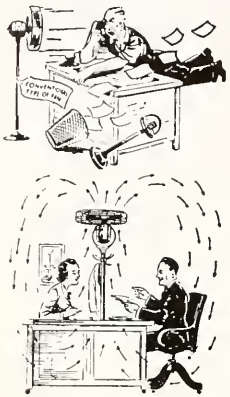
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GAS TURBINE

[*Continued from Page 25*]

ing of the crushed coal at later stages in the process.

Because the coal will have to be lifted from the low point reached at the discharge of the crusher, and it must also be intimately mixed with hot air in order to effect the drying, it seems reasonable to use a pneumatic conveyer and consequently the coal will be transported from the crusher to the pressure tank by a stream of air. By keeping the pressure in the coal-handling system slightly below that of the atmosphere, any leakage will tend to be inward, and the equipment can be kept clean much more readily.

Since the combustor will be operating at a pressure of 60 psi, it is going to be necessary to raise the pressure of the coal at least to this value. Three methods for pressurizing the coal are under consideration at the present time. Perhaps the simplest method is the use of two tanks, one of which will be filled from the conveyer system while the other is delivering coal under pressure to the combustor.

A second method is the use of lock hoppers, in the same fashion as sand blast equipment has operated for many years.

A third possibility is the use of an inclined screw feeder, which is caused to run full of coal, and to form a continuous plug at its upper end, which serves to prevent the leakage of air down along the screw.

Tests made at the Institute of Gas Technology have shown that, with a three-inch screw, it is possible to deliver at least twenty pounds of coal per minute with a rotative speed somewhat in excess of 200 rpm, against a pressure of 75 psi in the tank. This possibility will receive continued development because of its apparent usefulness in simplifying the control system and reducing the weight of the coal-handling equipment.

Pulverization seems to be a logical method of preparing the coal for burning because the few tests which have thus far been made on pressurized combustion indicate that powdered coal can be burned with a heat release of at least 750,000 Btu per hour per cubic foot. It is by no means impossible that the coal might be burned on a grate, but the practical difficulties of introducing the coal in large lumps and removing the ash seem to indicate that pulverization is a desirable step. It would also be very desirable to be able to gasify the coal before burning it, but thus far no satisfactory continuous pressurized producer has been developed, although this line of attack is being investigated currently by several organizations, including the Locomotive Development Committee.

The method of pulverization which is being developed by the Locomotive Development Committee is unique, and it seems to be well adapted to the combustion gas turbine. It has been found possible to pulverize crushed coal by the simple process of causing it to pass with compressed air through a nozzle, where the pressure on the coal particles is released almost instantaneously. This device, called the "coal atomizer", is a product of the research program of the Institute of Gas Technology at Illinois Institute of Technology in Chicago, and it was originally contemplated as a means of preparing coal for utilization in continuous water gas generators.

Figure 3 shows the general principle of the "coal atomizer", and indicates how its performance is effected by the pressure of the air and the ratio of air-to-coal. It is believed that the pulverization takes place by the continuous explosion of the air trapped in the pores of the coal. The coal is saturated with air just as soon as it is introduced into the high pressure zone, but this air cannot find its way out of the submicroscopic pores sufficiently rapidly to equalize the internal and external pressures as the coal passes through the nozzle. The net result is that the air which is trapped in the pores tends to expand, and it can only do so by shattering the coal. The use of a simple attrition device after the nozzle, to employ as much as possible of the kinetic energy in the coal-air stream, produces a fuel so fine that 80% will pass through a 325 mesh sieve.

The possibilities of this method of pulverization are being investigated both at the Gas Institute and at Johns Hopkins University.

The value of the coal atomizer in the gas turbine must be estimated by comparing the first cost and the probable operating and maintenance costs of a mechanical pulverizer with several moving parts and a large driving motor with similar costs for an auxiliary compressor, which takes air from the main compressor and boosts the pressure to perhaps 140 psi. The coal atomizer itself has no moving parts and there is reason to believe that its life is almost indefinite, aside from a certain minor degree of abrasion which can be prevented by using a hard material such as boron carbide for the nozzle. Somewhat less than two per cent of the shaft power of the turbine is required to drive the auxiliary compressor, and the only work which must be charged against the pulverizer is that required to boost the pressure of the air because when it enters the combustor, the atomizing air joins the rest of the air, and is equally effective in doing work as it goes through the turbine.

The problem of burning pulverized coal at a rate exceeding 1,000,000 Btu per hour per cubic foot is currently under intensive study. At the early stages of its investigation, the Locomotive Development Committee examined every available process for the burning of pulverized coal at high rates, and it appeared that the so-called Vortex combustor, developed by the Fuel Research Board of England, had already achieved heat releases approaching 500,000 Btu per hour per cubic foot under atmospheric pressure. This type of combustor has already been built at Battelle Institute for experimental applications, using a turbo-charger to supply the compressed air, and the first test reports are sufficiently encouraging to warrant continued work in this direction.

It seems apparent that the combustion of coal under pressure must be done in a two-stage process, because the total amount of air which is supplied in the gas turbine is from 600 to 700% of that theoretically required. The introduction into the primary combustor of such a large amount of excess air would certainly result in reducing the flame temperature to the point where incomplete combustion would prevail. Accordingly, coal-burning combustors are likely to resemble their oil-fired contemporaries in that combustion will be carried out as completely as possible in an inner chamber, while the cooling air will circulate in the space between the inner and outer shells and will mix with the products of combustion at some point along their path so that the temperature of the outgoing gases will be reduced to 1350 F.

Because of the very large amount of excess air, it is expected that slagging will not be a serious problem. First test results indicate that the fly ash is entirely dry, and that there is very little agglomeration. Some building up of light coke particles has been noticed, but this tendency can be overcome by better adjustment of the air supply. Fundamental experiments on the combustion of coal under pressure are going forward at Battelle Institute, using a simple single-tube combustor, lined with refractory and water cooled, in which pressure as the primary variable can be thoroughly investigated.

This work will be continued until virtually all of the important coals in the United States have been burned under pressure, and it is hoped that a body of authoritative information can be assembled which will be comparable to that published in the past by that institution.

One of the most important problems in the use of coal as a fuel for gas turbines is the removal of the fly ash. Fly ash removal in large stationary power plants is customarily effected by cyclone separators or electrostatic precipitators. The latter are out of the question for locomotive service because of their size and the necessarily low air velocity which would have to be maintained. Mechanical separators have advanced rapidly during the past few years, however, and it appears probable that a battery of small cyclone separators will be able to remove up to 95% of the fly ash. Tests on

(Continued on Page 44)

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[*Continued from Page 43*]

single-tube Aerotec units of two and three-inch diameters (Figure 5) at temperatures up to 1100 F. indicate that from 85% to 95% of the fly ash can be recovered. Likewise, the small fraction which escapes contains no particles larger than five microns in diameter. Tests made for the Allis-Chalmers Company, and kindly made available by it to the Locomotive Development Committee, indicate that particles five microns in diameter are relatively harmless to turbine blade material when carried in high temperature air streams. Extensive abrasion tests are planned for the near future at the Johns Hopkins University.

The method of removing the fly ash from the high pressure zone has not yet been determined. Actually, the quantities of ash which will be obtained are sufficiently small so that with a locomotive, it would be possible to collect the ash in a tank, and discharge it only at intervals when the locomotive is idle. Tests will shortly be made at Purdue University to see whether this recovered fly ash is effective as a rail sanding medium. If so, it may be possible to make use of a material which is ordinarily a nuisance. By removing 95% of the fly ash, however, the combustion products which will be exhausted to the atmosphere will be almost as pure as the air which is taken into the compressor. The solid content of the exhaust gas will be far lower in magnitude than is permitted by even the most stringent smoke ordinance.

Questions which are still to be solved are those relating to the reduction in efficiency which will be brought about by the use of coal instead of oil as the fuel. It is recognized that some penalty must be paid in the form of pressure drop in the fly ash separator but it appears now that one psi will be adequate to insure 95% fly ash removal. It may also be necessary to use a higher degree of turbulence in the combustor and thus use a greater pressure drop than would be necessary with a light oil. However, the solid fuel is in general sufficiently lower in cost to justify these sacrifices in efficiency.

As a matter of fact, the fuel cost using coal will be so low that the first cost of equipment, and its consequent carrying charges, will have to be given very careful consideration. Whereas temperatures as high as 1350 F. can be successfully employed at the present time, it may prove to be economical to use lower temperatures and hence, less expensive materials in the turbine and the regenerator. The usefulness of the regenerator is also a matter of considerable speculation, but in the locomotive, the improvement of partial load performance brought about by its presence is likely to prove to be an important factor.

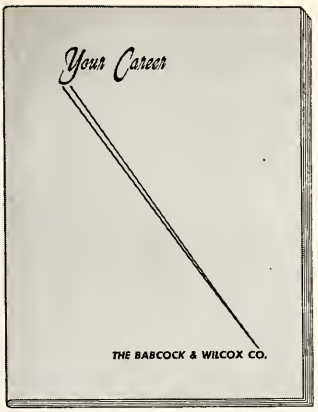
In summarizing the present status and future prospects of the coal-burning gas turbine, it may be said that the problem is one of development rather than invention, because most of the essential equipment is already available in one form or another. Problems of control still remain to be solved, but since the gas turbine usually requires at no-load approximately one-quarter as much heat intake as at full load, the matter of burner turn-down, of great importance in wide-range steam plants, is not so critical with the gas turbine.

With coal as its fuel, the cycle efficiency of the gas turbine can afford to be considerably more moderate than when light oil is used. It is probable that coal-fired units will be relatively simple, although they are likely to include a regenerator even if it is used only to preheat the combustion air.

The Locomotive Development Committee believes that the coal-burning gas turbine will be a tremendous contribution to the welfare of the railroads and the nation as a whole, because it should enable the nation's most important transportation service to operate economically with the nation's most abundant fuel.

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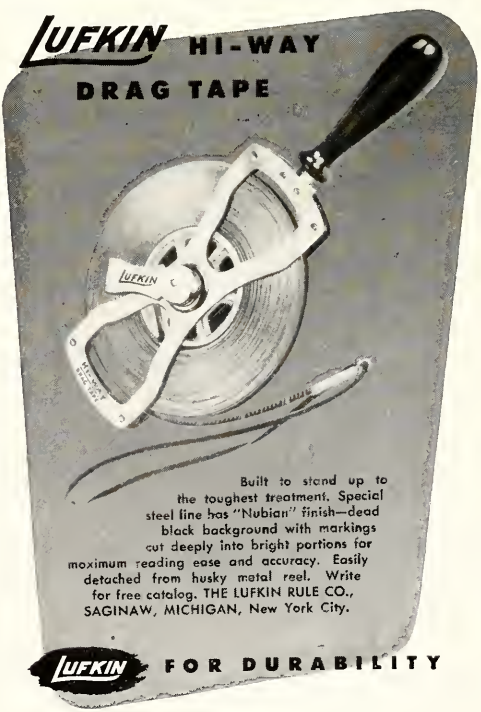


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RADIANT

[*Continued from Page 20*]

sure of at least two hundred pounds.

The vertical risers and other circuit pipes are usually installed in recesses formed in the walls or ceilings, and specially constructed hidden control valves are inserted in the riser or connecting pipe to each and every coil so that any coil can be regulated independently or isolated when so desired.

A flow adjuster valve should be installed in the return pipe of each coil because these are really essential to the complete success of the system. In the large buildings where there are invariably a number of rooms having doubtful exposure losses and surface temperatnres, these fittings provide an easy means to permanently regulate the flow of hot water for individual coils and produce a constant comfort effect in every room. They also provide a ready means to correct any slight error which may have been made in calculating the radiant heat surface required. All circuit pipes are connected to form a complete hot water circulation system, the water being accelerated through the various circuits by means of a centrifugal pump placed in the basement. Water is usually circulated at a temperature varying between 80° F. to 130° F. which gives an average surface temperature of 70° F. to 110° F., depending on the outside temperature conditions.

It is customary and advisable to install an automatic blending valve in the main flow pipe to blend some of the return water with hot water from the boiler and, where possible, it is an advantage to have a weather controlled device to give correct surface temperatures according to the outside weather conditions. It is also advisable that the circulating pump should be of ample capacity to maintain a good circulation in the coils with a small difference in temperature, as this gives a more uniform surface temperature.

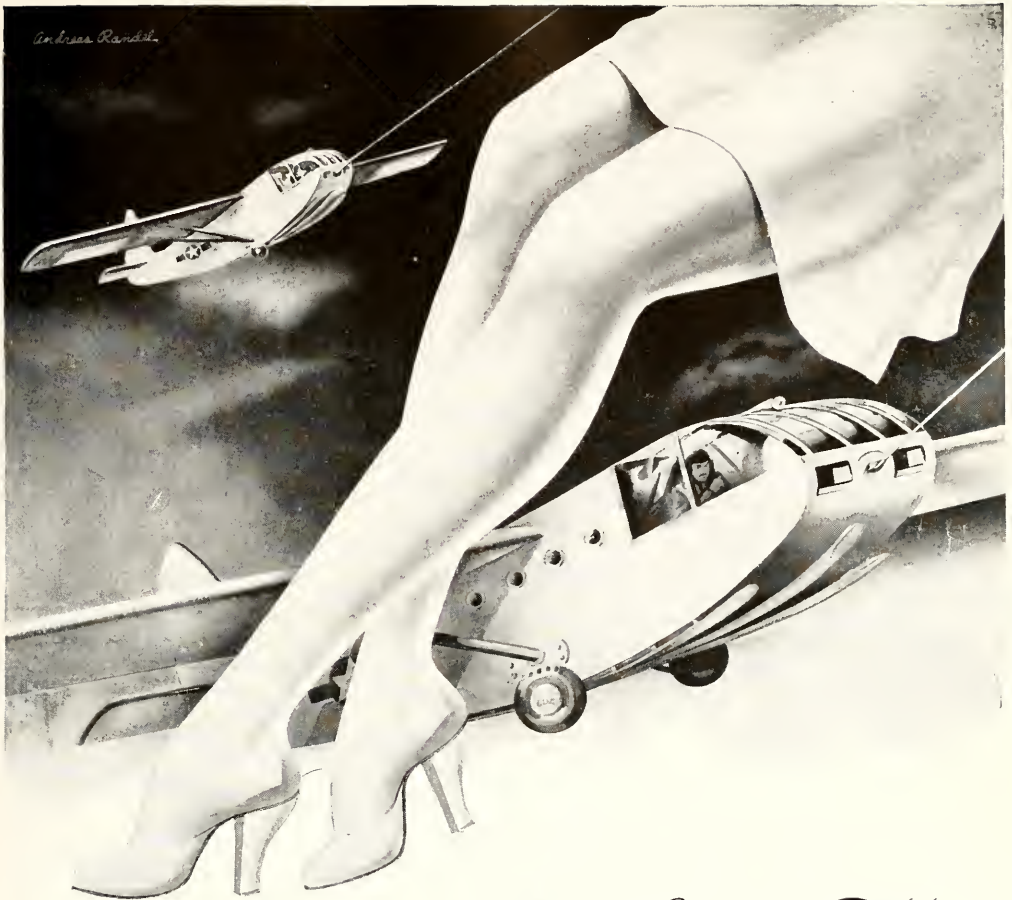
There are already nearly one hundred of these installations in America and so far every one designed and installed correctly has given good results. In England there are, of course, many hundreds which have been installed during the last twenty-five years, and although some have as many as forty thousand to fifty thousand welded joints, no trouble has resulted from leakage or from any other cause.

Unfortunately, there are in America a few unsatisfactory radiant heat systems which have been designed and installed by inexperienced people, or the calculations have been based on haste and erroneous conclusions deducted from a few tests which are misleading. This is particularly regrettable because radiant heating may receive an initial setback simply because the fundamental principles are not properly understood.

Figure 4 illustrates the method of installing similar pipe coils when hollow blocks are used in the floor construction. The usual method adopted when installing the pipe coils on the surface of hollow blocks is to support the coils in recesses and then cover same with plaster. Hollow blocks built into the floor construction makes a good non-conducting medium which prevents heat from passing upwards by conduction to the room above. The transfer of any large amount of heat in this manner would disturb the balance of heat in the rooms above.

Another method of providing radiant heat surfaces is to warm the floors by placing steam or hot water pipes in channels, similar to that shown in Fig. 5. The pipes may be formed into a continuous coil or fabricated into a grid. The pipes used with this under-floor space method are usually two inches in diameter, made of wrought iron through which hot water is circulated by gravity for small installations, while for larger jobs a centrifugal pump or accelerator is installed to obtain a quicker circulation. A flow adjuster should be installed in the return pipe of each coil, as recommended for coils embedded in plaster. The pipes forming these coils are

(Continued on Page 48)



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(Continued on Page 46)

usually spaced from twelve to eighteen inches apart, and a slight gradient is given from flow to return for eliminating air easily.

With concrete floor construction, parallel beams or supporting walls are formed between the pipes on which rest concrete slabs of suitable size and thickness to carry the weight. Any desirable flooring, either of well-seasoned wood blocks or wood floor boards, may be used to cover the concrete slabs; in fact, almost any flooring material may be used provided nothing is added which will become plastic with the heat. It will be noted that the larger pipes are not in contact with the floor construction, except at the points of support at each end. If large pipes are buried in a concrete floor, the surface temperature will be very uneven and the hot spots will be very objectionable to the feet.

In many of the schools having warm floors, it is found possible for the children to continue their studies with part of the walls removed. These schools have been specially designed with outside folding side walls, so that during school hours these can be opened, enabling the children to breathe natural fresh air while their bodies are kept warm by increased metabolism and the effect of the radiant heat from the floor. From observations made in these particular schools by the English Medical Research Committee, it has been proved that there is a remarkable improvement in the agility of children's minds and quality of their handwork.

There are, of course, many other methods of floor heating which can be adopted according to the particular type of building and floor construction. I have designed some successful installations by using small steam pipes under a wood floor, but great care has to be taken when using steam pipes in a floor, otherwise the temperature will be too high and tender feet will result. In my opinion, the most comfortable effect of radiant heat is to have a floor-heated room with the floor covered with rugs or carpets.

A somewhat unique design of floor heating is illustrated in Figure 6. It was designed after several months of careful research work to develop a suitable system for large cathedrals and other similar buildings. It may have been that the inception of this idea originated in the fact that the historical remains of a radiant heat system, which the Romans constructed two thousand years ago, were within a few miles of my home, giving me many opportunities to study the structure and ideas which have been closely followed on many occasions during the last twenty years.

The Romans with their hypocaust system made charcoal fires and allowed the smokeless fumes to pass through channels formed in the floor and in the walls. The surfaces of the walls and floor were thus warmed, which gave them the comfort they required. The principle of the system shown in Figure 6 is somewhat similar to that of the Romans, although, naturally, it is in many respects greatly improved, with mechanical means provided for circulating the warm air in the floor ducts instead of using flue gases.

The fan "B" circulates the air which is heated as it passes over the heater "A". It then passes into the main ducts and through the channels formed in the floor. The warm air system is entirely sealed so that no air can escape into the building or be lost in any way. The base or under-floor is virtually a concrete raft which extends throughout the nave, chancel, and north and south transepts, and forms a base for the circulating flues. Concrete divisional walls, "F", about four inches wide by twelve inches high and ten inches apart, are built up from the concrete base to form supports for the floor proper, and the air circulating channels between these divisional walls are connected alternatively to the main flow and return warm air ducts.

The warm air is conveyed from the heat "A" along the main duct "C" where part of the air passes through the openings "G" into flues "D". The area of the openings at "G" were cal-

(Continued on Page 50)

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[*Continued from Page 48*]

culated to carry the correct amount of air to each duct, depending on its length. The return air from the channels in the floor is conveyed through the small openings "H" into the main return duct "E" and conveyed back to the fan. Slate slabs about six feet by three feet and one and one-quarter inches thick are supported on the top of the divisional walls, leaving each flue or channel with a net area of one hundred twenty square inches.

The slate slabs supported in this way are sufficiently strong to support any possible weight, while on top of the slate slabs were placed white marble slabs about three feet by two feet and three-quarter inch thick. These marble slabs were bedded down with cement to form the finished floor of the cathedral.

Thus, the whole floor is one large radiator. The air channels in the floor are stepped up where the riser steps are formed from the nave to the chancel, so that the whole floor surface is heated uniformly, and the extreme ends of the chancel and nave are equally warm with the rest of the cathedral. Since every part of the floor is practically at the same temperature, there are no down drafts whatever, and no objectionable flickering of the candles which often is noticeable at the altar in churches and cathedrals heated by other methods.

There are a few items of special interest associated with this installation which may be worthy of note. The height of the cathedral inside is approximately one hundred thirteen feet, and the triforium walking way, which is carried along both sides of the cathedral at a height of ninety-seven feet above the floor, makes it possible to obtain very accurate observations of air conditions at high level.

When the temperature of the air taken at four feet above the floor was 60° F., the air temperature at the triforium level, more than ninety feet above, was 58½° F., just 1½° F. lower than at four feet above the floor. Without doubt, no other known method of heating could create these ideal conditions in such a high building. Tests in similar cathedrals where warm air systems have been installed show the air temperature at high level to be much too hot to be even tolerable.

Another remarkable feature is the thermal storage of the structure. It is found that if the oil furnaces are turned off, it takes thirty-six hours for the air temperature in the cathedral to fall 1° F. It has been found in actual operation throughout the winter that if the fires are operated for a few hours only each day, the temperature change is so small it cannot be detected on any thermometer, regardless of changes which may take place in the outside conditions. During the whole of the winter it is found that an air temperature of 58° F. to 60° F. will give perfect comfort.

Figure 7 illustrates another method of providing thermal radiations by using flat cast iron plates about three-sixteenth inch thick, on one side of which channels are formed to provide steam or waterways. These plates are made in various sizes and constructed so that they may be assembled together with ordinary right and left-hand thread nipples, making it possible to build up units of any size. These plates, known in the trade as "Rayrads", can be assembled into large units having a length of up to eight feet and a width suitable for the particular location. They can be placed flat against the wall or ceiling with a molding fastened around the edge to give them a very neat appearance as a raised flat panel, or they can be installed in recesses so that the surface of the panel is flush with the surface of the wall.

The surface of these metal plates may be covered with a wood veneer which can be oak grained or painted to blend with the woodwork in the room, or it can be decorated in other ways to harmonize with the furniture or other features of the room. Similar plates may be cast from special patterns to give a replica of oak panelling and formed into a complete or partial dado around the walls of a room or passage.

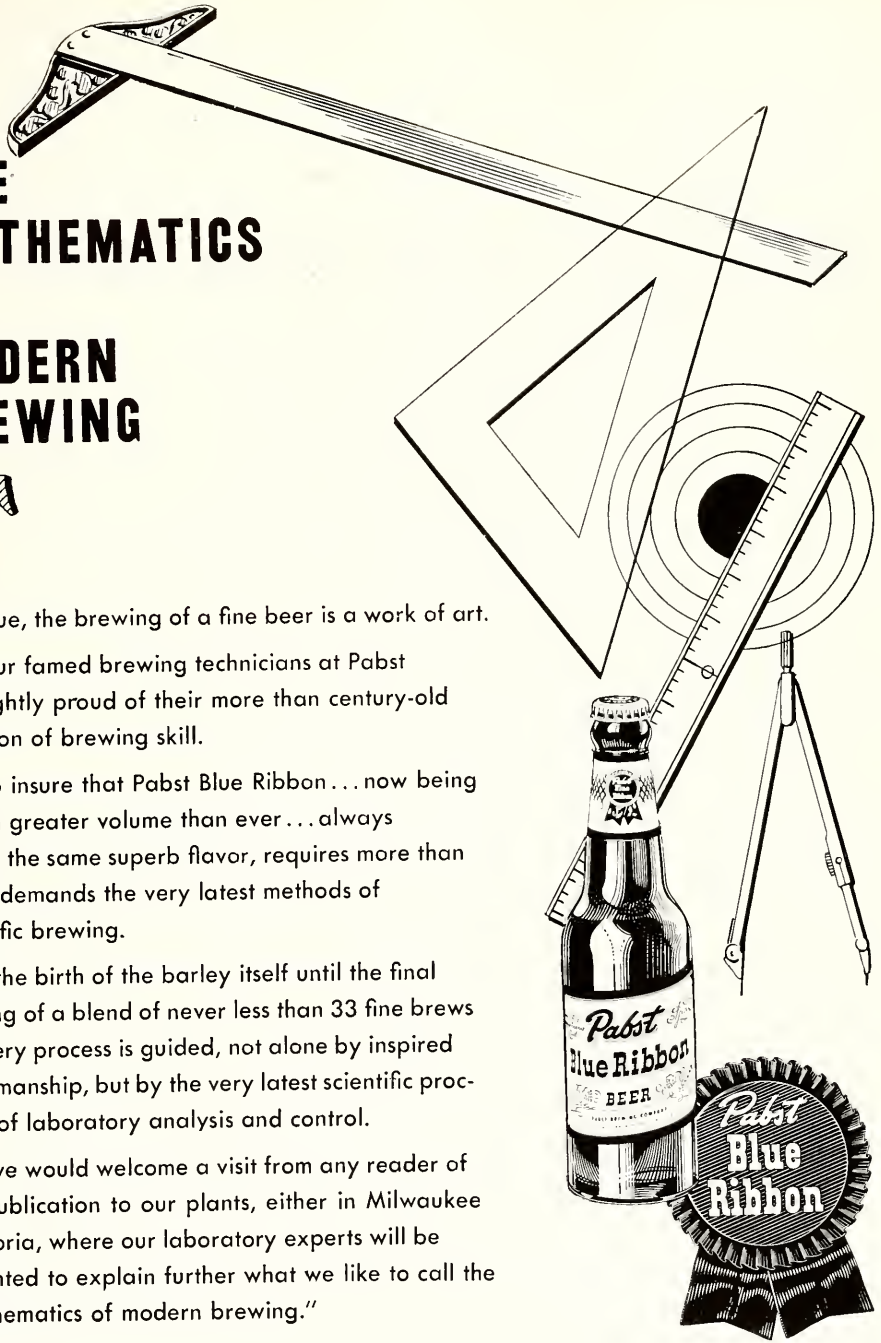
I have, with complete success, used a number of these cast iron panels in America to take care of cold spo caused by open doors and windows libraries where convector heaters i stalled could not effect a remed These plates may be easily installe in an existing building without entai ing a large amount of cutting aw or other builder's work, and since th metal will stand any reasonable ter perature, low pressure steam may l used as a heating medium. This mak it possible to use them in a buildir of any height, or connect them to a existing heating system. There is n more difficulty in connecting iro radiant panels than with a conve tional system of ordinary cast iro radiators. Instead of using cast iro panels, it is very easy to fabricat panels with sheet metal surfaces an wrought iron, steel, or copper coi spot-welded to the sheet metal plate I have designed a number of thes plates, some of which are installe in my plant, Sarco Company, at Beth lehem, Pa. Those in the office were ir stalled because the old system of hea ing left many cold spots in one larg office. Similar metal plates, in a actual installation which was a com plete success, are curved to form th ends of bookshelves in a library.

The above examples illustrates onl a few of the methods already adopte to supply radiant heat by using steam hot water and warm air as heatin mediums, but there are many electri al installations where the panels ar heated by using electric elements These elements are sometimes inserte in recesses formed on metal plates, o the heated conductor is formed as graphite resistor ribbon embedded i glazed fire clay or other similar ma terial.

Then again, very attractive portabl screens are made from tapestry i which the electric conductor is use as the weft and the fabric used as th warp. These screens are fitted with flexible connection which can be at tached to any electric outlets. The ad vantage of such screens is that they are portable and it is possible to pro vide local warmth for one's self whil reading or working at a desk withou

(Continued on Page 52)

THE MATHEMATICS OF MODERN BREWING



True, the brewing of a fine beer is a work of art.

And our famed brewing technicians at Pabst are rightly proud of their more than century-old tradition of brewing skill.

Yet, to insure that Pabst Blue Ribbon... now being sold in greater volume than ever... always enjoys the same superb flavor, requires more than art. It demands the very latest methods of scientific brewing.

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And we would welcome a visit from any reader of this publication to our plants, either in Milwaukee or Peoria, where our laboratory experts will be delighted to explain further what we like to call the "mathematics of modern brewing."

"It's Blended... It's Splendid!"

Copr. 1946, Pabst Brewing Company, Milwaukee, Wisconsin

[*Continued from Page 50*]

having to heat a large room. A similar method of forming electric conductors may be used in connection with tapestry which can be hung on the surface of a wall and provide radiant heat without disturbing the building in any way.

After many years of actual experience, it has been well established that the saving in fuel consumption with radiant heat systems is between 30% and 40%, depending on the type of installation, while with good controls the saving is even greater.

During recent years it has been found very desirable to use automatic temperature controls with radiant heat systems, operated by outside weather conditions. The advantage of this type of control is that it will effect greater economy and prevent time lags which might occur following exceptionally quick changes in outside temperature conditions.

Figure 8 gives an outline of such a control and the function is as follows: The blender valve is inserted in the main flow pipe, so that part of the water from the return is blended with hot water from the boiler, thereby maintaining the correct water temperature flowing through the system. The outside thermostat is sensitive to both air temperature and local low temperature radiation but is screened from direct rays from the sun. If the combined effect of outside air temperature and low temperature radiation is increased, the temperature of the water flowing to the system is automatically reduced, and vice versa. The auxiliary bulb is fitted with an electric heater which is connected to the room thermostat. Since the room thermostat is sensitive to air temperature and the mean radiant temperature of the room, the function of this combination is to further reduce the water temperature when the dual effect of air temperature and mean radiant temperature increases beyond comfort conditions.

Figures 9 and 10 illustrate this type of control as connected to various radiant heat systems, the principle of operation being the same in each case. Where the pipe coils are embedded in the plaster of walls or ceilings, hot water must be used as the heating medium and it is necessary to keep the maximum temperature of the water down to 130° F., or below, to prevent damage to the plaster. As the weather becomes milder, the water temperature is automatically reduced to meet the smaller heat losses, and it is for this purpose the "Sarcotherm" control is specially adapted.

Figure 9 illustrates this control applied to pipe coils embedded in the floors and it will be noted that the outside thermostat is placed on the outside wall of the building so that it can respond to the dual effect of air temperature and radiation losses, as do the walls of the building. The radiant heat ball-type room thermostat is shown in a key room to control the auxiliary bulb of the thermostatic system according to room conditions.

Figure 10 illustrates the same control as connected to a radiant system using "Rayrads" or fabricated metal panels. With this type of panel, higher water temperatures may be used, but it is equally advisable to have an automatic control to obtain the greatest efficiency. In this illustration the room thermostat and auxiliary bulb have been omitted, but these may be added if desired.

Other methods of control may be used, but intermittent control cannot be considered satisfactory since it defeats the object of radiant heat. With the modern type of building, a continuous circulation of hot water is essential to prevent any sudden fluctuation in room conditions.



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OHMITE

[*Continued from Page 11*]

are separate from the industrially sponsored research work done by the Laboratory, in that students will not be assigned to commercial projects.

Dr. E. U. Condon, Director of the National Bureau of Standards, Washington, D. C., in his address, "The Place of Precision Measurements in Industry," which he delivered at the June Dedication services, was emphatic in his insistence upon the fact that modern industry was dependent upon exact knowledge—not alone the accurate physical measurement of the length or diameter of a piece and the precise determination of thermal and chemical quantities, but also the application of electrical techniques as the basis of measurement, instrumentation, and control devices for every type of measurable quantity.

In his talk, "Cooperation Between Industry and Education," on the same occasion, Dr. G. Edward Pendray, Industrial Consultant, New York City, said there was need for an unobstructed understanding by industry of the role of education. He said that a "creative technology"—the art of discovering the secrets of nature and the development of this new knowledge, through the processes of research, engineering, and manufacture, into machines and products—depended upon finding, training, stimulation, and the utilization of technical men. He concluded by proposing a plan whereby industry could conveniently finance its share in the program.

The Ohmite Laboratory is proving a most valuable addition to Armour Research Foundation because of the breadth of opportunity it presents to both the Foundation and the prospective project sponsor. It is anticipated that it will be equally valuable as an additional educational facility for Illinois Institute of Technology and the Midwest.

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This coupling has done its share to make Koppers "the industry that serves all industry". Just as the designing and building of coke ovens, the production of chemicals from coal, the treating of timber, the making of roofing, paving, piston rings and many other products have played their part in helping Koppers to serve American industry and, in turn, the American public. Koppers Company, Inc., Pittsburgh 19, Pa.

The industry that serves all industry

KOPPERS

CITY NOISE

[*Continued from Page 14*]

measure the dollar loss resulting from the additional mental and nervous load we carry.

However there is a more serious aspect also to be considered. People who are forced to carry heavier loads than they are capable of carrying, frequently break down, become neurotic or psychotic. These unfortunate individuals must be cared for. We care for them through increased taxes. These go to maintain hospitals, public sanitariums and institutions for the confinement of mental cases. Already there are many such institutions and they are almost inadequate to care for the present load. Thus in the immediate future our tax load may be increased to build and maintain more such establishments.

An even more serious result is found when we carefully examine the newest findings of the medical profession. It is a fact that of the many illnesses we suffer, all of which are apparently physical, many actually are caused by mental and nervous disorders. Tight nerves or over-loaded mental equipment take revenge by causing organic breakdowns, such as stomach ulcers, and others, and in some cases may be the cause of such things as arthritis, diabetes, and other such diseases.

We cannot afford to ignore unnecessary noise. It is contributing to the nervous and mental overload which may actually make us sick. It may be that some people have so much money and so much energy that they can ignore the drains caused by unnecessary noise, but the more or less ordinary human being can't afford to dismiss the facts lightly. We must consider them and consider our personal contribution to the direct and indirect cost of noise in money and health.

What can we do about it? Let's ask ourselves some questions and give ourselves a chance to help. How much do we individually contribute to the general noise? Do we blow our automobile horn when it is not absolutely necessary? Do we speak more loudly than needful? Do we play our radio at full volume? Do we tolerate overloud signal devices in our homes or on our cars? Do we pay additional cost because of noise making inefficiency in the machine we own and operate?

If the answer to any of these questions is "Yes," then you can make a personal contribution to your own health and efficiency. By reducing or eliminating any of these noises we can make our lives better, saner, more healthful, and put profit in our pockets. Most important from your personal standpoint is to control the noise *you* contribute toward the general din. Do not use your horn more than absolutely necessary. Play your radio no louder than necessary for pleasure and enjoyment and reduce it to a minimum after eleven o'clock at night and before ten in the morning.

Scientific research has done its part in reducing needless noise. For example, at Illinois Institute of Technology's Armour Research Foundation, we have been able to reduce the noise from such devices as—office machines, fan belts, motors, and other industrial machines. These are to mention only a few. During the past several years scientific research has done much to reduce the noise of home appliances and office equipment. When you next purchase home or office equipment remember that quiet operation and efficiency frequently go hand in hand.

Several years ago, the Greater Chicago Noise Reduction Council became interested in this problem of unnecessary and harmful noise. We were in-

(Continued on Page 56)

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Pressure-welding also is used by many other industries. Some use pressure-welding for the construction of overland pipe lines . . . some for the fabrication of machinery parts . . . some for making oil-well tools . . . and some are using pressure-welding to make airplane and automobile parts.

Pressure-welding is a research development of The Linde Air Products Company and The Oxweld Railroad Service Company, Units of UCC.

If you are a bit technically minded or just want to know more about this subject, write for booklet P-5 on Oxy-Acetylene Pressure-Welding.

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[*Continued from Page 54*]

strumental in creating an early interest in noise abatement and one of our first steps was to get the City of Chicago more interested in cutting down noise. We called upon Mayor Kelly with the problem and found that he, too, was a strong backer of every effort to abate needless noise.

The Chicago Noise Abatement Commission was formed in July, 1943, as a civic effort to reduce needless noise. Since then the Armour Research Foundation has used its noise-testing apparatus to aid the Noise Abatement Commission in determining noisy spots, in order that effective means could be taken to cut down noise.

Annually, for the past several years, we have used this apparatus to test a dozen or more areas—again in both industrial and residential sections—to learn in what sections the most improvement could be made. Many persons think that because State and Madison Streets in Chicago comprise "the busiest corner in the world" that it would be the most noisy. Such was not the case as we learned from a recent test.

Wells and Lake Streets held the record for greatest noise. Tying for second place were the intersections formed by Van Buren Street and Wabash Avenue, 89th Street and Green Bay Avenue, and 92nd Street and Commercial Avenue. The intersection of State and Madison Streets ranked eighth on the list.

Another survey, again using noise-measuring equipment, similar to that pictured elsewhere in this article, showed what the top noise makers were in the order of their intensity and most constant repetition. In one year alone, the Noise Abatement Commission received 1,125 complaints about noisy motor trucks. A total of 1,087 persons complained about automobile horns.

Dividing the irritants into still further groups, it was learned that the most frequent offenders, in the order complained about, were traffic noises; those caused by transportation; too loud radios; whistles and bells from

(Continued on Page 60)

"But where are the Burton Stills?"

The Oldtimer was one of the group of visitors at the Whiting refinery, looking down from the roof of the ten-story power plant while our guide pointed out the new refinery units.



"But where are the Burton stills?" the Oldtimer asked. "Don't tell me there aren't any left in this refinery—the refinery where cracking was born!"

Invented in 1911 by Dr. William H. Burton, one of Standard of Indiana's early scientists, oil cracking increased the gasoline yield from crude and ensured an adequate petroleum supply for many years to come.

"The Burton stills produced millions of barrels of gasoline, and made a lot of money," said the guide. "They were the best in the world for a long time. But newer equipment has taken their place."

He pointed out over the refinery.

"Each of those big combination cracking units turns 20,000 barrels of crude oil a day into finished products—more than two or three small refineries. Over there you see the hydroformer. It produced during the war more toluene for TNT than the whole country produced during World War I. It also helped in the aviation gasoline program. Now it's being operated for high octane motor gasoline and solvents for the paint industry."

The guide showed us three or four more war units, and then a still more enthusiastic light came into his eyes.

"But even the war program was small," he said, "compared with the program under way now. That steel structure twenty stories high is the last word in fluid catalytic cracking. It will process 25,000 barrels of gas oil a day. Every three minutes a carload of catalyst will move through its transfer lines. The other new cat crackers will be just as big. And a new motor oil plant is being built right over there."

Later he showed us the site where steel girders were rising into place for the huge new research laboratories. These laboratories, he explained, will more than double the present large research staff. They will provide facilities where 1200 scientists and technicians will work with beakers and flasks and superfractionation columns—and slide rules and enthalpy tables and electronic analyzing devices.

As we finished our refinery tour, the Oldtimer's glance strayed again to the place where the Burton stills had been.

"I'm glad to hear you say the Burton stills were the best in the world in their day," he said. "We were always proud of the Whiting refinery. And I'm glad we can be even prouder of it now."

STANDARD OIL COMPANY (INDIANA), 910 South Michigan Avenue, Chicago 80, Illinois

EDUCATION

[*Continued from Page 13*]

The Humanistic-Social Faculty

The insistence that every course in the curriculum must be made "engineering education" is a demand upon faculty members in humanistic-social departments that they are ill prepared to satisfy. Our teachers of English and history, for example, are almost always graduates of liberal arts colleges and of university graduate schools. Their professional training has been that of teachers and scholars in the fields that they "profess." They are professors of English, etc., *not* professors of engineering. They have not been prepared by education or experience to strain after analogies with or allusions to peculiarly technological subjects. Until the engineering schools start producing their own teachers of "engineering-psychology" and "engineering-literature," they must consider as part of the data what the liberal arts colleges and graduate schools have and have not done to those who teach psychology and literature to engineers.

But even if they could, *would* faculty members in non-technical fields be willing to subordinate themselves, the disciplines they profess, and the students before them to the demands of a totalitarian "engineering education"? It is reasonably clear that self-respect and self-interest alike would require rejection of such subordination. No man of standing as a teacher and scholar in letters or the social sciences is willingly going to let himself be identified with a practice that filters all his subject matter through peculiarly engineering preoccupations. He has faith in the importance of his field for human beings, be they engineers or agriculturists or pharmacists, and if he loves teaching he is going to be eager to introduce his students to the good, the true, and the beautiful in his field of special competence. Not only has such a man his own values and convictions to consider; he has a professional reputation to maintain. He is a member of a learned profession, that of teachers and scholars in his field. If he values his professional standing, he will never consent to a distortion of his work that would unfit him, in fact or in appearance, for teaching in universities or non-engineering colleges.

Meeting Civilization's Deficit

Ultimately, the administrators of colleges of engineering have to decide what they want in the quality of humanistic-social studies in their institutions. At one extreme, they can zealously endeavor to attract and to retain a distinguished faculty in letters and social sciences—men who will stimulate and instruct their students, men who will substantially contribute to the reputation of their schools. At another extreme, administrators can fill faculty positions with mediocre hacks, tiresome to their students, dissatisfied with themselves, obsequious to administrative suggestions that they should never distract their students' attention from peculiarly engineering education. "What do you want? Pay the price and take it."

Our students in engineering colleges are in large part youths of high and varied capabilities. They often pay unusually high tuition. They deserve the best of instruction. Is the administrator honest with the students if he puts before them instructors who present without enthusiasm or competence an ill-digested and adulterated mess of hyphenated subject matters? Our teachers of humanistic-social studies in colleges of engineering deserve some consideration, also. Is the administrator honest to all his staff if inter-departmental meddling is encouraged, if attacks of non-engineers on our campuses are launched, if discrimination in salary and recognition is the ex-officio lot of hapless teachers who cannot escape? Is the administrator serving the good name of his institution if he helps create a situation that repels and alienates ambitious and able teachers and that gives other collegiate institutions justification in looking down on the quality of any of the work done in the engineering college?

One of the platitudes of our time is that our mastery of natural forces has outrun our development of humane values and of ethical and social insight and responsibility. Science and technology have placed explosives in the hands of a society still dangerously infantile and unregenerate. The production of purblind and unimaginative technicians is no great service to the world. It has been a well authenticated educational tradition that humanistic-social studies, more than scientific-technical ones, are or can be helpful in meeting the greatest deficiency of our civilization. If this be true, it is not desirable that humanistic-social studies should be engulfed in colleges of engineering by peculiarly engineering concerns. Rather it is needful that humanistic-social studies be accorded the independent status and dignity commensurate with their mission in the education of engineers.

Reprinted from the *Journal of Engineering Education*, Vol. 36 (May, 1946), p. 543.

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Du Pont *Digest*

Items of Interest to Students of Chemistry, Engineering, Physics, and Biology

America Learns to Make Its Own Camphor

FOR YEARS, the Japanese maintained a tight hold on the world's camphor supply.

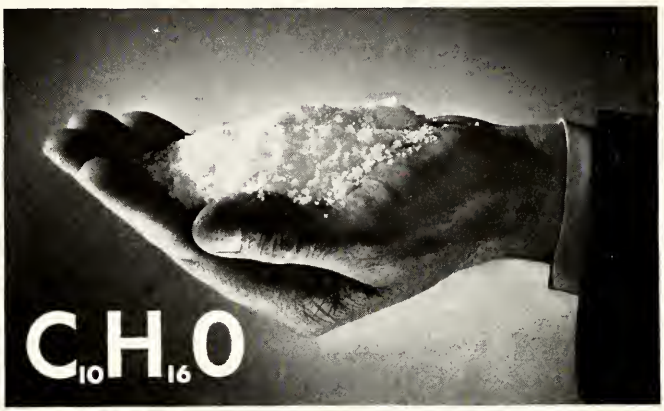
Americans had to have camphor in ever-increasing quantity for the manufacture of photographic film, celluloid, plastics, perfumes, medicines, lacquers and disinfectants. But they were forced to pay whatever price the Japanese chose to ask. And even at 1919's exorbitant top figure of $3.75 a pound, they were never sure of a full supply.

Men of Du Pont undertook to make this country independent of such an unsatisfactory source. They knew that camphor could be synthesized, but to make it at low cost and in large quantities was an entirely different matter. Long years of experiment and research produced little but disappointment. But finally, in 1932, a way was found to produce low-cost chemical camphor on a commercial scale that matched nature's product in color, texture, scent and usefulness.

$C_{10}H_{16}O$ from Turpentine

Basic material from which Du Pont camphor is made is pinene, obtained from turpentine from southern pine trees. The formula of pinene ($C_{10}H_{16}$) seems to differ but little from that of camphor ($C_{10}H_{16}O$), but the structural difference is considerably greater than is indicated by the single atom of oxygen. Although the chemical conversion of pinene to camphor is not difficult to accomplish in the laboratory, to do so economically on a commercial scale taxed the ingenuity of many Du Pont chemists, engineers and designers.

World War II completely shut off the supply of natural camphor. But within a few months Du Pont production men were able to step up the output of the man-made product to take care of military, medical and civilian needs. Today this supply is going into the manufacture of hundreds of products that will bring more comfort, more satisfaction, more joy into the lives of millions.



All the men at Du Pont—chemists, mechanical engineers, civil engineers, and hundreds of others who worked on this development—feel great pride that they were able to free their country from foreign sources for such a vital material in our industrial life.

• • •

SYNTHESIS OPENS NEW ERA IN PERFUME MANUFACTURE

Some of the most interesting discoveries at Du Pont have come from "fundamental" research groups assigned to establish new scientific facts without regard to immediate commercial use.

Synthetic musk is an example. Musk is the most important single ingredient used in perfumery, a fixative blending many subtle odors into one fragrance and making it lasting. Until recently its only source was the musk deer of Tibet, an animal nearing extinction.

Then Du Pont organic chemists, in their long-time study of giant molecules, noted that a group of ring compounds called macro-ketones resembled musk in odor. Following up their observations with intensive research, they produced compounds of even more pronounced likeness.

Now, in "Astrotone," perfumers are offered a synthetic musk that is of a determined strength, immediately usable and as powerful as the pure essence of natural musk.

Questions College Men ask about working with Du Pont

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There are many Ph.D.'s at Du Pont. However, the majority of our chemists, chemical and mechanical engineers, physicists and biologists are Bachelors or Masters. Every effort is made to see that full recognition is made of a man's scientific training, as well as his special experiences and aptitudes. For certain openings, a higher degree is a distinct asset.

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[*Continued from Page 56*]

factories; locomotives and tugs; construction noises; vocal irritants, such as newsboys, peddlers and barking dogs.

Noise is by no means an intangible thing. It is possible to measure it and entirely possible to do something about it. Traffic policemen and taxi cab starters were asked to use whistles only in cases of emergency. Manufacturing plants, many of which are necessarily noisy, made a concerted effort to banish needless noise.

School children were among the most helpful in putting the soft pedal on needless racket.

The Golden Rule works in noise, just as it does in everything else. What annoys you is more than likely to annoy your neighbor, or the people who work in your office, or your family.

The Noise Abatement Council each year awards a prize trophy to one city in each of four population brackets that makes the greatest reduction in noise and one grand trophy to the city making the greatest single contribution toward community noise abatement. For the past three years Chicago has won the award for the group of cities to which it belongs, the Class One group.

This has been possible because every citizen has cooperated with other citizens to reduce noise. Each year, under the leadership of the Greater Chicago Noise Abatement Commission the people of Chicago have done more than any other city in its group and those efforts have been successful.

The annual National Noise Abatement Week offers everyone an opportunity to work together with his neighbor to make his city quieter, and in so doing he can add new lustre to his community record and save himself strength, health, and money.

Note: This is the major portion of a talk prepared with the collaboration of the Greater Chicago Noise Abatement Council and delivered over radio station WLS, Chicago, on Saturday, May 4, at 9:15 A. M.

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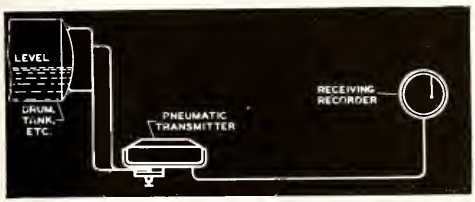
MONTREAL

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PNEUMATIC TRANSMITTERS

FOR THE REMOTE METERING AND CONTROL OF

Flow • Pressure • Level • Density



Typical installation for measuring liquid level

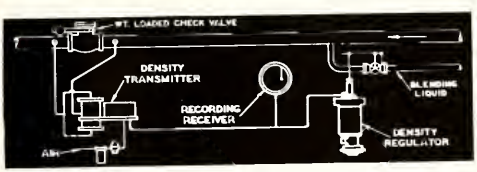
LEVEL

There are three types of pneumatic transmitters by which liquid level measurement and control, in either open or closed vessels, may be secured.

1. The differential pressure type, in which the level is measured between the liquid level and a known reference level.

2. The buoyancy type, in which the buoyant force exerted by the liquid against a displacer tube is measured. It may be installed with the tube inside the vessel, or may be arranged for mounting outside the vessel in which the level is measured. This transmitter is used where a condensable vapor is not present. May also be used to measure liquid-to-liquid interface.

3. The weigh tube type, in which the weight of the liquid in a tube is measured. It is suitable only for mounting outside the vessel. This transmitter is especially well suited for very high operating pressures or for the measurement of level of very corrosive liquids.



Typical installation for measurement and regulation of density

DENSITY

Republic pneumatic density transmitters are ideal for the measurement and control of the density of a liquid flowing in a line.

Transmitters can be furnished for liquids of densities from 0.5 sp. gr. (compared to water at 60°F.), to the heaviest liquid known.

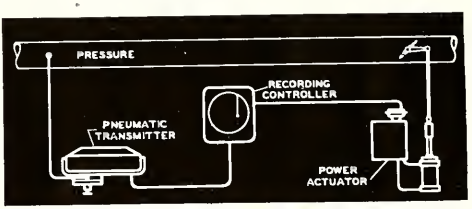


Typical installation for measuring flow

FLOW

Republic pneumatic transmitters are particularly adaptable to the flow measurement and control of steam, water, gas, air or oil at static pressures up to 600 lb. per sq. in. They are built to operate on differentials as low as 0.9 in. of water and as high as 800 in. of water.

Pneumatic transmitters are also provided for the flow measurement of viscous or vaporous liquids which will either congeal or vaporize in lead lines exposed to atmospheric temperature.



Typical pressure control installation

PRESSURE

Ideal for installations where it is undesirable to run long pressure taps due to safety hazards. Built for pressures ranging from 1.0 in. of water to 1500 lb. sq. in.

ADVANTAGES

Republic pneumatic remote metering and control systems permit the desirable centralization of process records without the necessity of running lines containing poisonous or explosive products into control rooms. They also eliminate the necessity of running long lead lines to flow meters or pressure gages with the consequent troubles due to vaporization or freezing of the lines. The transmitter is located close to the point of measurement and the value transmitted pneumatically to some distant point where it can be either indicated, recorded or controlled.

WRITE FOR DATA BOOK No. 1000

REPUBLIC FLOW METERS CO.

2240 Diversey Parkway, Chicago 47, Illinois

CRANKCASE

[*Continued from Page 28*]

Speed	3150 R.P.M.	(Corresponding to 60 miles per hour.)
Load	30 B.H.M.	
Oil Temperature (sump) (SAE 10 grade oils)	265°	
Oil Temperature (sump) (SAE 30 grade oils)	280°	
Outlet water temperature	200°F.	
Air-fuel ratio	14.0:1 to 15.0:1	

5. *General Motors 500-hour Test.* Conducted in a "71" series 2-cycle Diesel engine, 3 to 6 cylinders, at conditions of a test used at the engine factory to determine performance of engine components under maximum load and speed. This test is rather severe on both engine and lubricant. It is used to evaluate oxidation stability, detergency and copper-lead bearing attack in addition to other features peculiar to 2-cycle Diesel engines. Operating conditions are as follows:

Speed	2,000 R.P.M.
Oil sump temperature	230°F.
Jacket water outlet temperature	180°F.
Power output	25 B.H.P. per cylinder
Oil change periods	none
Filter	AC - S13

Specification 2-104B requires only the L-1 and L-4 engine tests on oils compounded from base stocks and additives of known performance; all five tests are required (on the SAE 30 grade) when an unknown additive is used or when an unorthodox refining procedure has been used in the preparation of the base oil.

A much asked question is, "Why is it necessary to conduct engine tests on oils?" The author's answer is always that this is the best method he knows of and that if there were better methods he would certainly want to use them. Actually, it is a little embarrassing for him to admit not being able to recommend a less expensive and less cumbersome method of evaluating oils and point to the evidences of lack of correlation between physical inspections, bench test data, and engine test results and call attention to the great deal of work being done to improve the inspections and tests to obtain better correlation and to supply more fundamental data. Engine testing is still in the increase in use, and this eases the analyst's conscience when he admits failure to suggest an alternate but equivalent testing means.

The use of small-scale engines or prototype units is particularly useful when large numbers of oils are to be investigated. The evaluation of a series of additives used in varying concentrations and with different base stocks calls for too many tests to be handled other than by bench or small-scale engine tests. Considerable attention is being given at this time to the development of suitable engines for this purpose. It is certain that full scale engines will be used for some years to come in the same way they are now used, with bench tests a small-scale engine tests used in a supplementary capacit

If researchers are agreed that engine testing is nec sary, the logical procedure is to use it and to obtain much information as possible from it. It is particular important that the results be analyzed for their possib contribution to fundamental knowledge of the behavi of hydrocarbons rather than be considered superficial as tests which must be tolerated and passed. The esta lishment of suitable standards for classifying and ratir the test results is an important step in the most effecti use of the tests. For example, color standards are avai able to assist in assigning a numerical value to varnis deposits on pistons from the L-4 test; these should b improved to include considerations of area covered an thickness of deposit. Deposits in ring grooves, which ma be one of the more important considerations in a tes are difficult to describe and standards should be d veloped to denote quantity, hardness, location and po sible ring interference. In lieu of suitable standard lengthy descriptions are used. Analysis of used oil sample according to the ASTM procedures gives numerical dat but unfortunately this data is often difficult to interpr and is sometimes only valuable when compared wit similar data on oils using the same additives. Syste used for rating results are open to further criticism fo lack of agreement in "weighting" given the various fa tors. The researcher's aims should then be to:

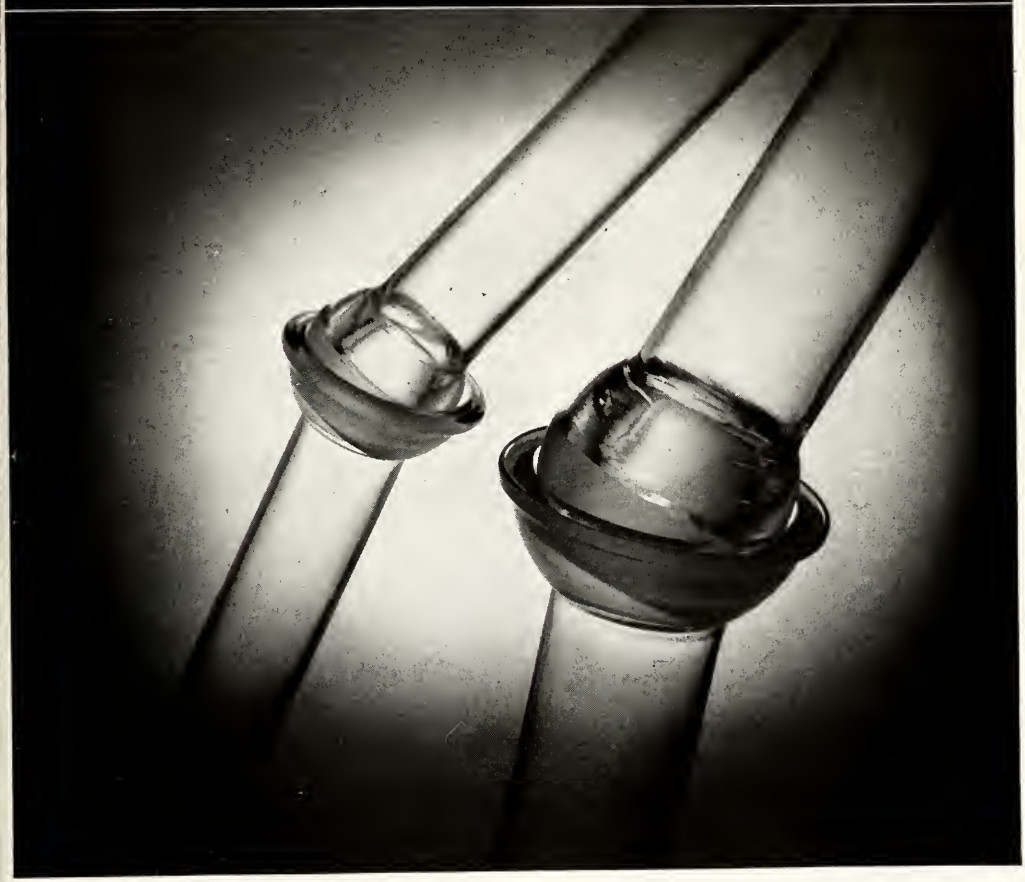
1. Devise improved rating standards for engine test parts.
2. Improve chemical and physical inspection methods applicable to the used oil.
3. Reduce the effects of operating variables and fuel, or control them.
4. Increase the reproducibility of engine tests by use of precision parts and precise control of all phases of preparation and operation.
5. Develop reference fuels and lubricants which have clearly defined characteristics.
6. Improve test engines especially to evaluate individual characteristics of an oil rather than a complex combination of characteristics.

Since the cessation of hostilities the qualification o heavy-duty oils has been carried on as it was during th war. The Ordnance Engine Oil Reviewing Committe inspects the engine test parts, operating data, used oi sample analyses, and any other pertinent informatio and makes its recommendation to the Ordnance Depart ment. Members of the Committee are:

Ordnance Department, F. & L. Branch
General Motors Corporation, Research Laboratorie Division
Caterpillar Tractor Company, Research Departmen
Chrysler Corporation, Research Department
Armour Research Foundation, Engine Research Section

(Continued on Page 64)

Have you heard about our "Glass Knees"?



THEY look like little knobby glass knees. But to a laboratory worker this jointed glass tubing is a real blessing.

You've seen nightmare arrangements of glass tubing, flasks, and jars in "science" movies. Real laboratories have them, too. And the job of connecting a maze of tubing—with rigid glass joints that slip together like a fishing rod—is a tough one. Everything has to be lined up just right. And then a shock or a blow may break the rigid tubing and you have to start all over again!

So laboratory people weren't displeased when Corning came out with a tough leakproof ball and socket joint. It sets up and takes down easily. Parts are interchangeable, due to precision grinding. And it permits slight movements of the apparatus without leaking or breaking.

The answer to this glass problem was fairly easy. Others have been more difficult. The builders of the Lincoln Tunnel in New York wanted glass tiles for walls and ceilings that would reflect light but not glare and wouldn't catch dirt. A man in Berkeley, California, who was building the first "atom" smasher" asked for glass parts that could withstand the terrific heat of 8,500,000 electron volts. Chemical manufacturers needed piping that would resist the corrosive action of hot acids.

Corning research and manufacturing skill solved these glass problems. Keep this in mind wherever you wind up after school. It is entirely possible that the intelligent application of glass to many of your problems may lower costs and raise quality and performance. When the time comes, we'd like to help you find out. Corning Glass Works, Corning, New York.

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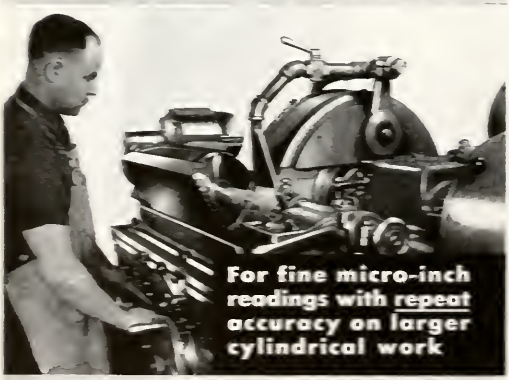
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Brown & Sharpe Mfg. Co. Providence, R. I., U.S.A.

BROWN & SHARPE

[Continued from Page 62]

Following each of the meetings of the Committee, the Armour Research Foundation prepares a complete report of the material presented, this report including a critical inspection of all of the test parts, color photographs and, for the sake of uniformity, certain black and white photos in which special techniques are necessary for a true photographic reproduction. This report also includes any special data submitted, such as laboratory and field test data; information on the preparation of the base stock and additives; and sometimes probable relation of new oil to present products in the marketing program of the company. All indications are that the Ordnance Department will continue to "qualify" oils and that lists will be prepared by some of the engine companies recommending the use of these oils.

Although heavy-duty oils continue to occupy a leading position in development aspects, the so-called "premium" oils are also the subject of extensive development, and in many ways the problems are more complex than those applying to heavy-duty oils. "Premium" oils are those having known oxidation stability and bearing corrosion preventive properties and need not have detergency to make them suitable for use in Diesel engines. These oils are the middle quality product of the API classification, heavy-duty, premium and regular. At the present time the Chevrolet 36-hour test is the accepted method for determining oxidation characteristics, but the standards are not clearly defined and general agreement on acceptable oxidation resistance level has not been reached. Generally, the L-4 rating standards may be assumed to apply to premium oils. Highly refined oils will usually require only oxidation inhibition; conventionally refined oils will tend to form oil insoluble oxidation products and will usually require some detergent along with the oxidation inhibition in order to avoid excessive sludge formation. The L-4 test does not give complete assurance of good performance in the field since the type of fuel used, the engine, and the type of operation will all have an influence. Bench type tests may be used with more assurance in the development of premium oils since the degree of correlation may be expected to be better with the L-4 test only than with both the L-4 and L-1 tests.

A recent survey by the author disclosed the use of over 40 bench type oxidation tests in use throughout the world. Degree or correlation of all of these tests has not been established and only three or four of them are enjoying wide usage.

The future of research and development in lubricating oils and in chemical additives seems quite promising. Over 2,000 patents have been issued to date disclosing materials for beneficiation of lube oil. Engine testing will certainly play a major role in these development programs which will result in better lubricants, more satisfactory power plants, and reduced operational costs.

From an address before the National Petroleum Association, Department of Standards and Tests, on March 23, 1946, at Warren, Pa.

Straight talk about your after-college job

No. 5 A Good Engineer Must Go on Learning

AS BACCALAUREATE SPEAKERS are prone to point out, a degree in engineering is not the ending—but only the end of the beginning.

Here at The Timken Roller Bearing Company, a firm made up largely of engineers, we know it to be a fact that *what* and *how much* an engineer learns during the first years following his graduation usually have a decisive effect on his future.

It seems to us highly important for a young engineer to locate where he will have an *opportunity* to learn.

That is why a job with The Timken Roller Bearing Company has so much to offer sound-thinking, ambitious young engineers.

■ To give these men the chance to go on learning and developing, our company operates a "Work-as-You-Learn" Plan of training. No classroom work is involved; only productive work in the various departments of our factories and steel mills.

While performing a wide variety of jobs, trainees work with many engineers who are considered the best in their field. They have the chance to observe methods and ask questions about every operation in our business. All the while, they are closely watched. When particular aptitudes show up, trainees are assigned to the line of work for which they are best fitted.

But that does not end the learning period. To be successful in this company, an engineer never can afford to stop learning.

■ We do business with every industry in America. Our engineers are in continuous contact with the top engineers in hundreds of companies in every phase of enterprise. They must keep pace, or in many cases, *keep ahead* of progress in every industry. Because of that, this company deliberately fosters a restlessness—a "never-be-satisfied" spirit among its men as a spur to do the job better.

If you are willing to accept the challenge of continual progress which a job with this company offers, we would like to talk with you. The first qualification for training under our "Work-as-You-Learn" Plan is a Bachelor of Science degree in Engineering. Write The Timken Roller Bearing Company, Canton 6, Ohio.

The Timken "Work-as-You-Learn" Plan of Training

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4. Automotive Application Engineering
5. Railway Application Engineering
6. Alloy Steel Production and Sales
7. Purchasing Department
8. Field Engineering Service
9. Sales Order Department
10. Sales Engineering in Field

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College, the all-important next step, demands the fullest consideration of the WOMAN OF TOMORROW. College work, college degrees, and, the more important, learning to live that is the dividend of a well-rounded education, are all vital to her future. Much of the success of her education and future achievement depends upon her choice of college.

Illinois Institute of Technology, centered in the great metropolitan area of Chicago, is ideally situated to bring the benefits of the best in a college education to women whose homes are in or near the city. The Placement office provides exceptional employment opportunities.

Outstanding, not only in the Chicago area but in the nation, is the Illinois Tech department of Home Economics, with the professional work of the department concentrated at the new Downtown Center, 18 South Michigan Avenue, overlooking beautiful Lake Michigan.

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The curriculum in Home Economics is divided into majors in textiles or dietetics with opportunities open for graduates as dietitians in hospitals and institutions, teachers in elementary and high schools, managers of cafeterias, nutritionists in public health work, or home economists with testing laboratories and other business organizations throughout the United States.

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September 11	February 6
Evening Term	Evening Term
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- ☐ Psychology
- ☐ Sociology

PRE-PROFESSIONAL

- ☐ Dentistry
- ☐ Law
- ☐ Medicine
- ☐ Nursing
- ☐ Pharmacy
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